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SANITATION IN THE CONTROL OF INSECTS AND RODENTS OF PUBLIC HEALTH IMPORTANCE--TRAINING GUIDE, PART IV

Wilfred H. Johnson

Communicable Disease Center
Atlanta, Georgia

1960

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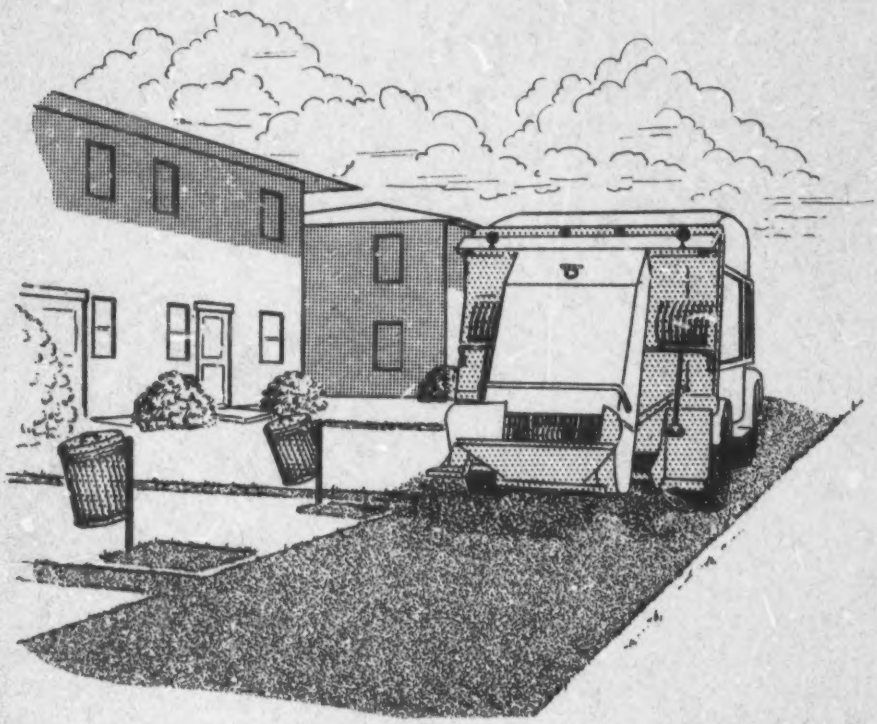
TRAINING PROGRAM

SANITATION

IN THE CONTROL OF INSECTS AND RODENTS OF PUBLIC HEALTH IMPORTANCE



U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

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SANITATION

IN THE CONTROL OF INSECTS AND RODENTS OF PUBLIC HEALTH IMPORTANCE

TRAINING GUIDE - INSECT CONTROL SERIES

WILFRED H. JOHNSON, Sanitarian (R)

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Communicable Disease Center
Atlanta, Georgia
1960

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Insect Control Series: Part IV

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SANITATION

IN THE CONTROL OF INSECTS AND RODENTS OF PUBLIC HEALTH IMPORTANCE

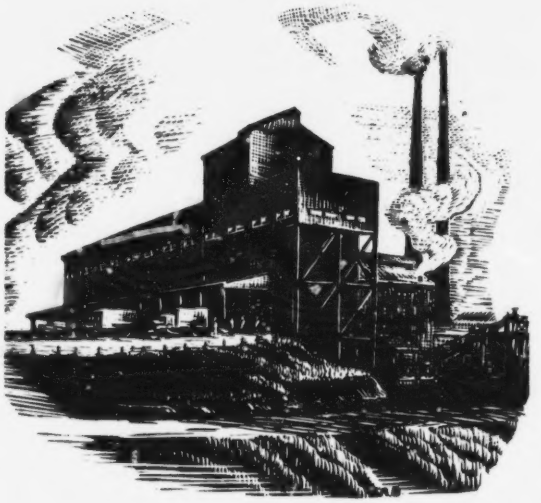
INTRODUCTION

General

Sanitation is the most important principle in the control of flies and rodents. This concept is also of considerable importance in the control of mosquitoes, particularly in urban areas. Sanitation has been defined as "A modification of environment in such a way that a maximum of health, comfort, safety and well-being occurs to man." It is, essentially, applied animal ecology effecting a modification of environment which results in conditions adverse to the continued existence of certain vectors and pests. Only recently has the necessity of this approach to vector-control been realized.

Research and community demonstration programs have shown conclusively that the application of the basic principles of sanitation results in substantial reductions in the fly, rodent, and mosquito populations. In a number of communities it has been estimated that proper refuse sanitation will do 90 percent of the job in fly control and 65 percent in rat control. In most communities, good refuse sanitation, together with good general maintenance of premises, will greatly reduce the pest mosquito population.

The methods formerly relied upon almost exclusively, namely, chemical and mechanical control, still hold an important place but should be looked upon as adjuncts or supplements to the basic, biological approach. The failure of chemicals to insure complete and lasting control has resulted in the current change of emphasis in this field. In the case of rodents, reducing the capability of the environment to support a large number of rodents not only decreases this population but results in an increase in competition between those individuals remaining. This increased competition results in a lower rate of reproduction and higher mortality.



Scope of Chapter

Insect and rodent infestations in homes, in businesses, and on farms result from neglect of basic responsibilities for cleanliness. Food, harborage, and water – life essentials for insects and rodents – occur frequently in and around all types of buildings wherever these vermin prevail. Vermin prevalence increases rapidly as the standards of maintenance and living drop. Substandard housing and business and industrial neighborhoods produce and maintain greater and more widespread vermin populations than well-kept, clean residential and business areas. Lack of knowledge, carelessness, and indifference are usually the basic reasons for the existence of such conditions.

A successful approach to resolving such problems and developing an effective program involves public education and promotion of sanitary practices by the individual and the community. Results

of the 1951-1954 inventory of municipal refuse storage, collection and disposal practices by the Public Health Service reveal some improvement of community programs in the last decade (Hope *et al.*, 1956). *(27)* This inventory also showed that the use of open dumps for disposal was practiced by 80 percent of the reporting cities with a population under 5,000, and by 35 percent of the reporting cities in the 50,000 – 100,000 population group.

Sanitation in insect and rodent control includes the three phases of refuse handling: *storage, collection*, and *disposal*, together with premise maintenance and the proper storage of products and materials. Emphasis will be placed here on the relationship of each activity to the existing or potential insect and rodent problem.

Definitions

Because of the varying definitions of refuse and its components, it is desirable to define the terms* used herein to avoid mistandings.

REFUSE: All putrescible and nonputrescible solid wastes (except body wastes). Refuse includes garbage, rubbish, ashes, street cleanings, dead animals, abandoned automobiles, and solid market and industrial wastes.

GARBAGE: Putrescible animal and vegetable wastes resulting from the handling, preparation, and consumption of foods.

RUBBISH: Nonputrescible solid wastes (except ashes). Rubbish consists of both combustible and noncombustible materials, such as paper, cardboard, tin cans, yard clippings, wood, glass, bedding, crockery, metals, and similar objects.

ASHES: Residue from the burning of wood, coal, coke, or other solid combustible materials.

*Refuse Collection and Disposal for the Small Community 1953 (47).

Refuse Characteristics and Quantities

In a 1951 study of quantities of refuse, principally residential, collected in 13 California cities, it was found that each person produced an average of 2.05 pounds of refuse every day. In volume, this is equal to approximately 0.147 cubic feet per capita per day. Two of the 13 communities produced slightly over 4 pounds per capita per day. (An Analysis of Refuse Collection and Sanitary Landfill Disposal, 1952). *(49)* At the present time average residential refuse production in the United States probably exceeds the average of 2.05 pounds per capita per day as reported in the California study. Total community refuse (commercial and residential) averages between about 3 to 5 pounds per capita per day. Numerous factors, such as geographic location, season, social and economic character of the community, types of business and industry, and type and frequency of collections, influence the amounts of refuse collected in a community. Some of these factors may also have a direct bearing on the existing or potential insect and rodent problems. The volume of garbage produced per capita is declining with the increased use of frozen packaged foods and other highly processed and prepared foods "ready for the pan or table." At the same time there is a corresponding increase in household rubbish such as paper containers, cans, and bottles.

REFUSE STORAGE

Effect on Vector Populations

Like other living organisms, rats, flies, and mosquitoes must have food, harborage, water, and suitable breeding media. The inadequate or improper storage of refuse offers all of these. Improperly stored garbage provides food for rats and flies, and a breeding media for flies. Improperly stored rubbish often offers harborage for rats and furnishes ample breeding sites for mosquitoes. Increased urbanization, with the attendant overcrowding of the human population in many sections of cities and towns, has made the refuse handling problem more acute and the environmental factors for insects and rodents more favorable. The growing areas of substandard housing in communities are much more important than fringe residential building as a factor in the favorable environment for insects and rodents.

Modern trends toward greater use of prepared, packaged, and frozen foods undoubtedly will continue to reduce the garbage content of mixed refuse, a change that will be accelerated by the increased use of home garbage grinders, the conversion of coal heating systems to oil and gas, and the decrease in back-yard burning of refuse. But while modern food merchandising is materially aiding in the reduction of vector and nuisance populations, it does not preclude the necessity for proper storage. Regardless of the composition of refuse, in general the extent of fly and rodent infestation closely parallels the degree of carelessness and neglect attending refuse storage.

Responsibility for Refuse Storage

In most communities adequate refuse storage on the premise is the individual responsibility of the occupant. However, the local health department should have the authority to require sanitary refuse storage at all premises. Proper refuse storage involves more than merely providing a sufficient number of containers to hold the volume of refuse produced between collections. It also involves selection of an approved type of container; placement of containers where they will provide maximum convenience for the user, yet be readily accessible to the collection crew; the proper prestorage handling of garbage and other putrescible wastes; and the maintenance of the containers and their surroundings in a sanitary condition.

The collection agency should instruct citizens as to their responsibilities in refuse storage. When these instructions are followed, general sanitary conditions will be improved; and collections will be more efficient. More garbage will be adequately stored, and more containers will be located at a convenient place at the proper time. One successful method of informing the public is the use of a printed card, which describes the storage practices required and gives collection schedules in different sections of the community.

Several cities supply the containers and retain ownership, charging the user a fee for service and replacement. In this manner the city is able to standardize the size and shape of the containers, thereby increasing the ease and efficiency of collections and at the same time contributing to sound fly and ratproof storage. In a few municipalities where the city owns the containers, the can exchange system is used. The full container is picked up and replaced by a steam-cleaned empty container. This relieves the home owner of the responsibility of maintaining the container, but it is expensive for the community and consequently is seldom used.

Household Treatment of Refuse

In the prestorage treatment of refuse, a number of simple yet important steps can be taken by the premise occupant which will be advantageous both to him and the municipal department responsible for collection and disposal. These measures, together with good storage, will reduce rodent food and harborage, fly breeding, and some mosquito breeding at homes and commercial establishments.

Garbage requires more prestorage treatment than other types of refuse. Draining household garbage and then wrapping it in several thicknesses of newspaper before depositing it in the containers have numerous benefits for the house-

holder. It reduces the possibility of disagreeable odors developing, either in the containers or during collection and disposal, and it makes the garbage less accessible to flies. Corrosion of cans is reduced, and washing is required less frequently. Since cans are more easily emptied when garbage is wrapped, the likelihood of can rims being damaged is greatly reduced. If the containers are filled only loosely, the contents do not freeze or stick to the inside, thus further lessening the likelihood of damage to can rims during emptying.

Draining, wrapping, and loose packing of garbage have benefits for the city, too. It reduces the time required for crews to empty cans and makes the task less disagreeable for these workers. When disposal is by incineration, this type of treatment greatly facilitates burning, and, when disposal is at a sanitary landfill, the drained and wrapped garbage creates less odor and is less attractive to flies.

If hog feeding is the local practice for the disposal of garbage, wrapping is undesirable from the point of view of the feeder. Draining, however, is highly desirable for storage and collection purposes, and it is simple for the feeder to add the necessary amount of water to gain the right consistency during the cooking process. Obviously, when hog feeding is the method of garbage disposal, rubbish and nonedible garbage must be separated from edible garbage and an additional method of disposal provided. Combined storage of nonedible garbage and household rubbish would be advisable provided approved containers were used. Even if household rubbish is separated and stored apart from garbage, it should be stored as garbage, for many items such as discarded cans, bottles, and papers have adhering to them a film or fragments of organic matter, which will attract flies and rats and furnish them limited food.

Rubbish often comprises the major portion of accumulated wastes. Much of it is combustible, hence can constitute a real fire hazard when not disposed of promptly. Since many items are so bulky, e.g., cardboard boxes, magazines and newspapers, tree limbs, old furniture, and large metal containers, they are difficult to handle unless proper precollection preparation is effected. Such items should be disassembled and tied in bundles or otherwise reduced to a size and weight that can be handled by one man. Ordinarily, bundles should not weigh more than about 50 pounds, and their length should not exceed 4 feet (this length may vary, depending on the size of the collection vehicles in use). Rubbish that has not been properly prepared often is left behind by collection crews, thus providing harborage for rats or breeding places for mosquitoes.

Shortly before collection time, the bulky rubbish, properly prepared, should be placed adjacent to refuse containers at the point of collection. In many areas, this type of refuse is collected separately on a less frequent schedule than other refuse and must be placed for collection on the designated day.

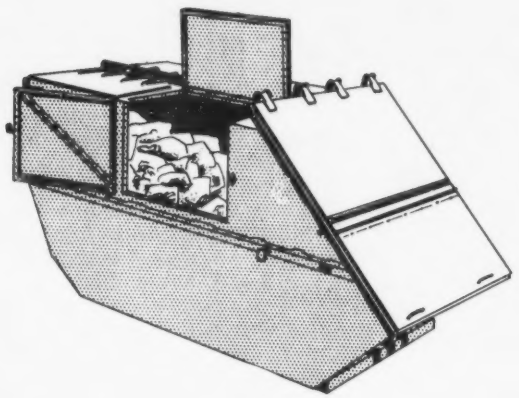
Containers

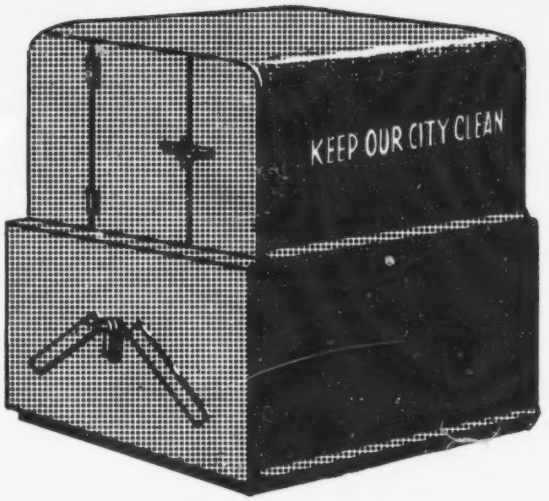
Garbage cans should be: (1) water tight, (2) provided with a tight fitting lid, (3) rust resistant, (4) structurally strong to withstand handling stress, (5) easily filled, emptied, and cleaned, (6) of a size that when full can be conveniently handled by one man, and (7) furnished with side handles or a bail. The conventional heavy-duty galvanized garbage can with the recessed bottom most nearly fits these recommendations. Each home or establishment should have a sufficient number of these containers to hold all the refuse that accumulates between collections. Hope *(27)* found that most communities favored containers of 20- to 30-gallon capacity. For garbage, when collected separately, 5- to 12-gallon containers are frequently used. Some communities limit the combined weight of container and contents to about 65 pounds.

Sunken garbage cans have the advantage of being out of sight, impossible to overturn, and inaccessible to dogs and cats. They provide some protection from summer heat and winter freezing. Their disadvantages include: (1) the pit is difficult to keep clean, (2) greater lifting effort is required of collection personnel, (3) the method is not suitable when ground water is high or rainfall is heavy, (4) maintenance cost for hinges and cover is high, and (5) initial cost is high. Generally, the disadvantages outweigh the advantages.

Bulk storage containers are usually quite satisfactory at apartment buildings, housing projects, or business establishments. Commercial firms produce movable bulk containers of various sizes that are efficient and serviceable. If desired, these containers can be hauled directly to the point of disposal, emptied, and returned by a specially designed truck-mounted hoist. However, new methods that do not require the transportation of each individual container to the disposal site have

recently been developed. Containers may be emptied directly into a large compactor-type truck capable of receiving the contents of a number of bulk storage units.





The bulk storage containers are completely enclosed and are made of heavy-gauge steel. They eliminate the fire hazard of rubbish, are relatively fly- and rodent-proof when properly used and kept in good condition, and can be padlocked to prevent scavenging and "free loading." To prevent fly breeding, these bulk storage units should be thoroughly cleaned each time the contents are removed. However, where containers are emptied into collection trucks at the storage site, adequate cleaning may present a problem.

Stationary bins for bulk storage may be allowed in some situations. Such bins, constructed of masonry or other ratproof material with tight-fitting lids or doors covered with sheet metal, could be acceptable where large volumes of dry rubbish uncontaminated by putrescible material are to be stored. Most designs for such bins do not allow for easy emptying, which is a pronounced disadvantage.

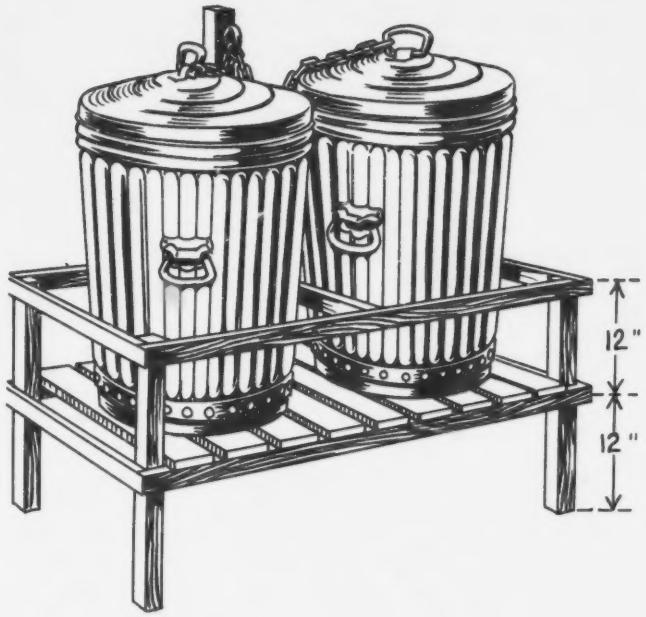
Wooden crates, baskets, and boxes are often used for bulk storage of rubbish. This practice is undesirable since garbage, or material contaminated with garbage, finds its way into these receptacles. Such misuse provides food and harborage for rats and permits fly breeding. The use of fire-proof, vermin-proof containers for rubbish is recommended.

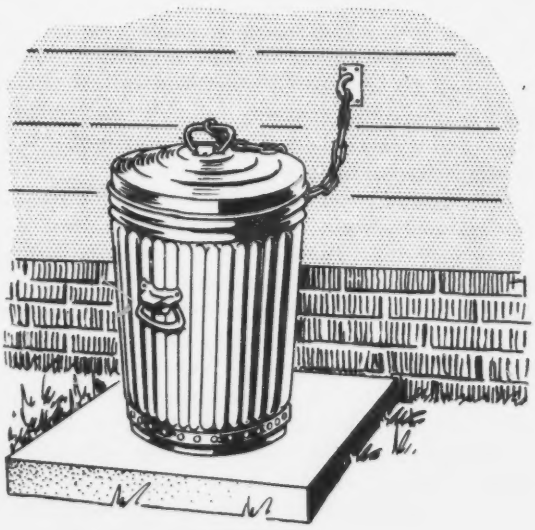
Garbage houses, if properly constructed and maintained, provide a satisfactory storage area for a large number of containers. However, because these installations are expensive to build and maintain, and are so frequently misused and neglected, they are seldom recommended.

Container Racks

Storage on the premise can be greatly improved by providing and maintaining proper storage racks or stands for refuse. Sketch plans for satisfactory racks of various designs and materials can usually be obtained from local or State Health Departments. Types of holders that have proved adequate include: (1) a single steel post with hooks to which the garbage cans are hung by the handle or bail, and sometimes with a stirrup to support the bottom of the container; (2) a pipe rack either of threaded or welded construction; (3) steel bars such as those used in reinforcing concrete, or angle iron, welded together; (4) single 1- or 2-can racks built of wood, of either new or scrap lumber.

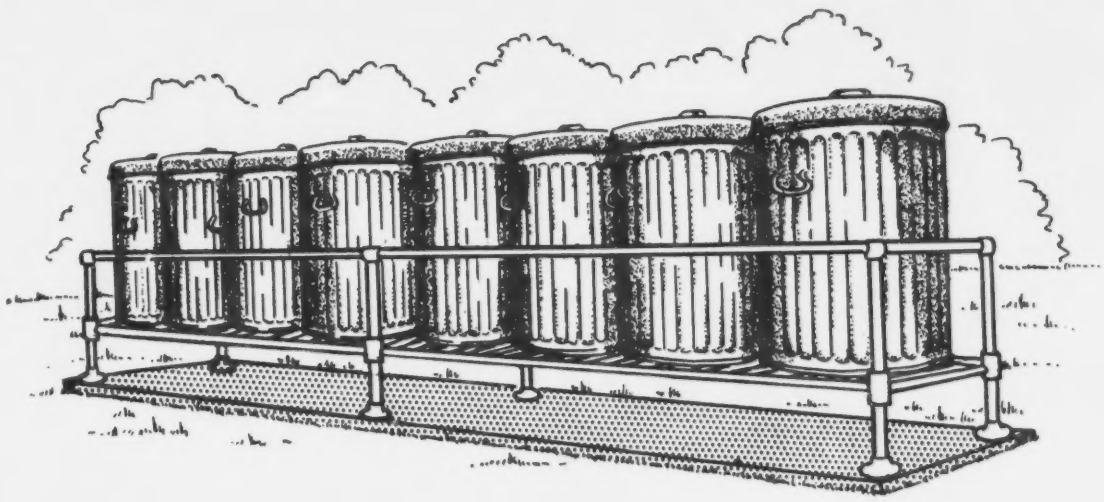
All storage racks should have open "slatted" bottoms and should hold containers at least 12 inches off the ground. This elevation not only reduces corrosion of containers; it also allows room for regular cleaning underneath, eliminates rat harborage under containers, and minimizes the possibility of cans being overturned. In areas where yard collection is practiced and the owner need not carry the cans to the curb or the alley for emptying, chains attaching container lids to the racks prevent loss of lids and minimize possible damage. Painting racks improves their appearance and in some instances prolongs their life.





Around apartment houses not served by bulk storage units, where there are large concentrations of containers, open-mesh wire fences around the racks will keep dogs and inquisitive children away from the cans. The purpose of the fence is not to enclose and hide the containers from sight. Therefore, solid enclosures are not recommended, as they tend to encourage carelessness.

Concrete slabs under individual containers provide some protection but are not generally as satisfactory as racks. When these are used, tney should be about 4 inches thick and should have foundation toes on the outside to prevent rodents from burrowing under them. Continuous slabs of concrete adjacent to apartments and business buildings, especially if elevated to truck loading height and provided with drains, are quite satisfactory. Many establishments prefer multiple-can racks somewhat removed from the buildings. Some restaurants, super-markets, and other establishments use refrigerated, inside storage rooms. This practice reduces objectionable odors in the garbage-storage area and, when garbage will be fed to hogs, helps preserve the quality of the garbage until delivery at the farm.



Location of Refuse Storage Area

The location of refuse containers, except on the days of collection, is usually selected for the convenience of the premise occupant. Commonly, this is near a side or rear door of the home or near the rear door of the business establishment. Where the community provides yard collection, it is not necessary to change the location on collection days. Where curb or alley collection is practiced, the occupant must move the containers to the point of collection on the days designated.

If the distance between the back of the house and the rear property line is not too great, and alleys exist, containers are frequently located permanently just inside the property line. This is convenient for the collection crew and not too inconvenient for the householder. In addition, this permanent location at the point of pick-up eliminates the possibility that the premise occupant will forget to place the containers at the alley on the day of collection. When this occurs, as it often does, the storage facility soon becomes overloaded; and garbage and rubbish are left exposed to flies and rats.

Where the distance between the back of the house and the alley is so great as to inconvenience the occupant, or where curb collection is practiced, containers usually are stored solely to suit the occupant's convenience and are moved to the point of collection on the proper day. Better maintenance of racks and containers will result when they are exposed to the scrutiny of the neighbors.

Proper Maintenance of Refuse Containers

The responsibility of the householder does not end with the emptying of the container by the refuse collection crew. Post-collection maintenance is especially important in fly and rodent control, as well as in odor control. Where curb collection is practiced, the householder should return the containers from the curb to the normal storage location as soon as possible after collections have been made. This will minimize the possibility of damage to the container and lid and will reduce the time during which flies would have access should the collectors fail to replace lids.

If garbage is adequately wrapped, or if a paper lining is used in the container, frequent washing may not be necessary. When any liquid or solid residue remains, it should be washed from the can, preferably into the sewer system. This is important, for extensive fly breeding occurs in accumulated garbage in the bottom and on the sides of containers. Schoof, Mail and Savage (1954) *(42)* report that garbage in containers represented 38.3 percent of the fly infested media in Phoenix, Arizona, in 1951 and 1952. If the container is washed and the washings emptied on the ground, food scraps may

provide rat food and fly-breeding media, and the liquid so saturates the ground that in time the earth itself contains sufficient nutrients to breed flies. After the can is washed, it should be inverted and allowed to dry before re-use. During insect seasons, spraying cans and racks with insecticides may be desirable.

If, in the process of collection, the container or the rack has been damaged, repairs or replacements should be made promptly. Rodent- and insect-proof storage does not exist where containers are materially damaged. The area around the racks should receive frequent attention to see that no refuse is allowed to remain outside the containers in which flies might breed or on which rats might feed.

Summary

In any community the insanitary storage of garbage creates a major source of food for flies and rodents and a breeding medium for flies. Rubbish that is not stored properly and disposed of promptly provides harborage for rats and a breeding place for mosquitoes. It poses a fire hazard and frequently is an attractant for flies. Good refuse storage can be attained with the expenditure of reasonable effort and is just as important in the small community as in the large city. Regardless of the size of the community, costs of collection decrease as good storage facilities increase.

Citizens should be encouraged to handle refuse properly. When education and information fail to stimulate satisfactory practices, local governments should enforce suitable ordinances that will require the practice of good storage. Even the small town that plays no part in actual collection, but instead relies on householder-contract arrangements, can still regulate storage of refuse, through education of its citizens and enforcement of modern ordinances for control. Model ordinances may be found in the U. S. Public Health Service handbook entitled, "Refuse Collection and Disposal for the Small Community," *(47)* or may be obtained from State and county health departments.

Good refuse storage in the urban community can become a reality. The whole community benefits through the reduction of vector and pest populations, through elimination of unsightly storage areas, and especially through the improvement of individual and community self-respect.

REFUSE COLLECTION

Importance of Collection

Refuse collection is an essential part of a well organized refuse handling system and has an important bearing on local vector populations. If a community has no collection service, conditions are generally favorable for high fly and rat populations. Even where service is available, a careless collection employee may spill refuse on the premise or on the street, thus providing food for rats and flies and a breeding place for flies. Rough handling may damage the container rim so that the lid will not fit properly, thereby making the refuse accessible to flies and rats. Negligence or carelessness in this manner may also create an odor nuisance. Frequent, systematic, reliable collection service should be the goal of every community. If this is not available, capacity of storage facilities will be inadequate and makeshift containers will be used, thus making refuse more readily accessible to flies and rodents.

A municipality without adequate collection service does not fulfill its responsibility to the community. Furthermore, it violates its moral obligations to its suburbs and to adjacent rural areas, for the roadside dumping that develops is an especially important problem in the vicinity of communities where collection is nonexistent or inadequate.

Collection Agency

Careful thought must be given to provide a community with the most satisfactory collection system. A decision as to the most feasible method of disposal for refuse will have a direct bearing on the type and operation of the collection system. If the community does not accept its responsibility for providing refuse collection and disposal, the householder will find it necessary either to haul and dispose of his own refuse, and usually this is done in an unsatisfactory manner, or to contract with a private hauler to make the collections.

Private collection in a community has a number of disadvantages, the most important being incomplete coverage. It is in substandard residential areas that this situation most often prevails, since many residents of such sections cannot afford the

private service. In the absence of municipal collection and disposal services, these people dispose of rubbish and garbage in their back yards, alleys, and streets, thereby creating the most favorable conditions for rats, flies, and mosquitoes.

City contract collection overcomes the major disadvantage of the individual method. With this system the city signs a contract with one or more individuals or firms to provide city-wide collection. Since service is scheduled for the entire city, complete coverage should result.

In some towns the municipal authorities contract with a hog feeder for collection of garbage. The incidental collection of rubbish may or may not be included in this contract. If collection of rubbish is not included and the city makes no other provisions for its removal, the householder must handle his own rubbish problem. Frequently, this permits an accumulation of rubbish, which provides rat harborage and a source of mosquito breeding. It also results in the use of large numbers of backyard burning cages and drums. When improperly operated garbage-feeding hog farms are located within a radius of 3 or 4 miles from a town, they may contribute to the fly and rat populations in that community. Flies and rats breed in large numbers where insanitary conditions exist and will travel considerable distances.

Other variations of the contract system are in use in a number of cities. For example, some cities own all the collection equipment, but the collection service is operated and supervised by a private individual or firm under contract. Many fringe areas, basically urban, yet not within the corporate limits of any municipality, are being served by county or district refuse collection systems. Some of these also serve numerous unincorporated communities not in fringe areas of a metropolis. A few cities will collect refuse immediately outside their corporate limits, charging a monthly fee for this service.

Municipal collection by city personnel using city-owned equipment is probably the most desirable and satisfactory method of collection from the public health viewpoint, and, when operated on a reasonably efficient basis, should be more economical than any of the various contract methods. In addition, it gives the city complete control over the operation of the collection service and the disposal method, and it facilitates close supervision of refuse storage. Each year more cities are operating their own refuse collection service, and fewer are using contract collection. Current practices regarding responsibility for collection of refuse are shown in table form in "Refuse Handling Practices in the U. S." *(27)*.

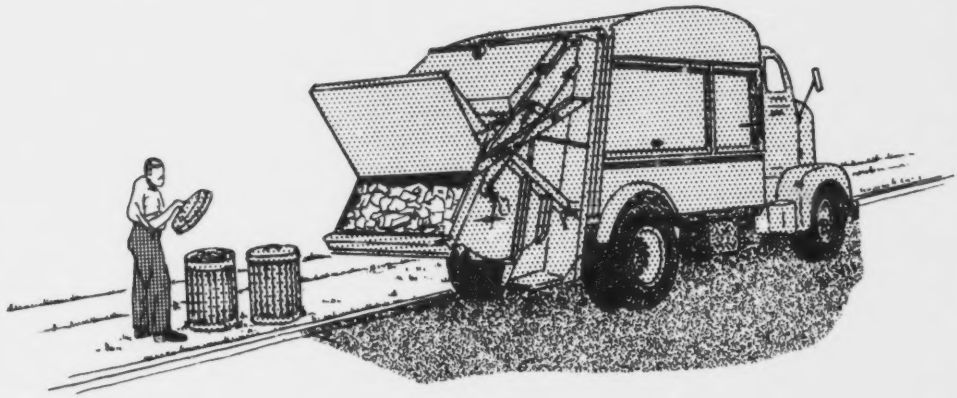
Type of Collection

The type of collection is determined largely by the method of disposal. *Separate collection* following segregated storage is necessary if hog feeding of cooked garbage is the method of disposal. Household garbage may require some sorting before it is safe to feed. Institutional garbage and garbage from hotels and restaurants are usually more suitable for hog feeding. Most State laws require that garbage used for hog feeding must be adequately heat-treated to kill animal disease organisms.

Combined collection of mixed refuse is the most practical and economical method and is possible where disposal is by sanitary landfills or by modern incinerators. Combined collection usually permits combined storage, thus preventing some abuses and conditions conducive to higher pest and vector populations that often exist where separate storage is practiced. Since garbage must be collected frequently, this combined collection allows no excuse for an accumulation of rubbish that might serve as harborage for rats or as a breeding place for mosquitoes.

Point of Collection

Alley or curb collection is probably the most economical because it reduces the pickup time for each premise. According to the information presented by Hope *(27)*, 43 percent of the reporting cities specified either curb or alley, or both, as the point of collection. Forty-five percent reported the points of pick-up to be various combinations of curb, alley, front houseline, and rear houseline, or front or rear houseline exclusively. Where curb collection is practiced, communities should urge the occupants of premises to return containers to their customary storage area as soon as convenient after the contents have been removed by the collection crews.



Yard collection is practiced by a number of communities. In this type of service the collector enters the premise and collects the refuse from the normal storage location. This is done in several ways: the collector may carry the containers to the truck and then leave them on the curb, or may return them, or he may have a tub or burlap square into which he empties the refuse from several homes before returning to the collection vehicle. Yard collection is more convenient to the occupant of the premise but obviously is more time-consuming and expensive.

Refuse collections are usually made in residential areas during the day and in the downtown business districts at night in order to avoid heavy daytime traffic. Larger cities, more frequently than smaller communities, practice nighttime collection in business districts.

Collection Equipment

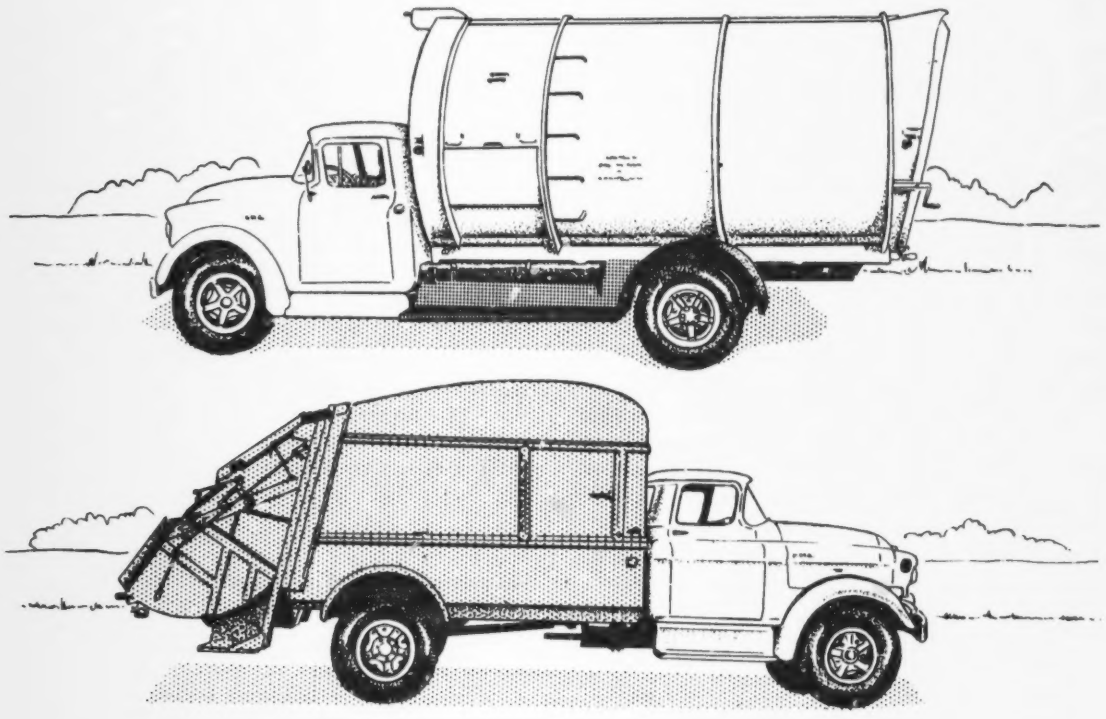
Great improvements in design and operation of refuse collection equipment have been made in recent years. These improvements have been accompanied by greatly increased capacities. Modern, enclosed, liquid-tight truck bodies prevent the spillage of loose material that so often happens when open truck bodies are used. They also prevent leakage of liquids from the vehicle onto city streets, which creates an odor nuisance and attracts flies. Enclosed trucks also minimize odors emanating from the contents. Trucks with low loading height reduce the danger of employee injury. Compacting mechanisms increase the load capacity, thereby reducing the required number of trips to the disposal site. Shorter wheel base on the vehicle chassis makes it more maneuverable in narrow alleys. All of these desirable features are incorporated into many models currently available. Capacities vary between 9 and about 38 cubic yards.

Open trucks may still be used for certain classes of refuse. Tree limbs, yard trimmings, bed springs, discarded hot water heaters, and other noncompressible items, together with ashes, may be collected in these vehicles. Tarpaulin covers, to be tied down over full and partial loads, should be used on open trucks.

All collection vehicles should be kept clean to discourage flies and rats and to avoid an odor nuisance on the city streets they traverse. When equipment is not cleaned regularly, flies may breed in the sludge and grease that adheres to the bottom and sides of open trucks or within enclosed or compactor-type bodies. This adhering material may also support a limited rat population in the area where the trucks are stored.

To avoid these health and nuisance problems, thorough cleaning at the end of each day's use is recommended. However, when putrescible organic matter is washed from collection vehicles, disposal of the wash water should be through municipal sewers. It should never be allowed to soak into the earth, thus creating an attractant for flies and rats and a breeding place for flies.

When collection equipment is antiquated or worn out, it should be replaced as soon as possible. Operating equipment in poor condition may result



in spillage or leakage on city streets, or in delayed collection following breakdowns. Delayed collections result in conditions similar to those existing when service is infrequent or when collection is otherwise unreliable, namely: the overloading of refuse storage facilities. When collection equipment is overloaded or overworked, additional trucks should be acquired. Standby equipment should be available in the event of emergencies.

Data on the types of vehicles currently used in collecting refuse are given by Hope *(27)*. According to this report, a survey revealed that of 337 cities having municipal collection, 46 percent relied on open vehicles for the collection of refuse. About 10 percent reported use of covered vehicles, only about 10 percent used compactor-type vehicles exclusively, and the remaining 34 percent used combinations of open and enclosed vehicles.

Information revealed that of the cities reporting contract collection, 60 percent used open vehicles and only 15 percent used compactor-type vehicles exclusively or in combination with open trucks. Of cities reporting private collection arrangements, 75 percent used open vehicles; and only 10 percent reported use of compactor-type vehicles exclusively or in combination with other types.

Comparison of these figures suggests another advantage to municipal collection, that better equipment is more frequently used where municipally operated systems are in effect.

Frequency of Collections

Collection frequency has a definite bearing on refuse storage and therefore exerts an influence on fly breeding, rat food and harborage, and even mosquito breeding. Where garbage is collected separately or in combination only once each week, conditions are favorable for high fly production within the community. If some circumstance allowed flies to have access to the garbage before or after emptying the container or between collections when the occupant was placing refuse in the can, eggs may be deposited. Then there may be time before the garbage is collected for large numbers of fly larvae, ready to pupate, to migrate from the garbage in the container to a drier medium. Also, where garbage collection is infrequent, storage facilities are frequently overloaded; and garbage becomes readily accessible to flies and rats.

In some smaller towns where garbage is collected separately, rubbish collection may be furnished only twice a month or monthly, and in some incorporated towns a semiannual "cleanup day" is the only rubbish collection service offered by the municipality. When rubbish collection is infrequent and irregular, accumulations of rubbish offer rat harborage and furnish artificial containers for mosquito breeding.

If the community disposal system requires that garbage and rubbish be collected separately, in

residential areas the garbage should be collected at least twice a week during the fly breeding season to hold fly production to a minimum, and rubbish should be collected at least once each week. In business districts all refuse should be collected daily.

When combined refuse collection is practiced, service should be provided at least twice a week during the fly breeding season and once a week in all other seasons. This practice will favor sanitary storage and will contribute to an environment adverse to flies, mosquitoes, and rats.

The inventory reported in "Refuse Handling Practices in the United States" *(27)* reveals that there is still much work to be done toward realizing sufficiently frequent collection in this country. Of 284 cities, only 197 reported collections of garbage twice a week or more frequently during the summer months. Eighty-five, or about 30 percent, reported that collections are only once each week, while two reported collections of less than once a week.

Collection Crews

Trained crews, realizing the importance of their work, willing to handle the premise occupant's property carefully, and able to meet the householder courteously when necessary, constitute a valuable asset to an effective collection system.

Careless crews can destroy public cooperation by damaging containers so that they are no longer acceptable for refuse storage. Owners can sometimes rightfully blame poorly trained crews for dented rims, bent and smashed lids and cans, lids completely missing, damage to can holders or racks, and spillage near containers. All these results of negligence are conducive to higher pest and vector populations. It is very difficult to induce people to buy new containers when they have experienced such service.

Crews should be well trained. Careful handling of personal property of all types should be emphasized to the crew members. Uniforms provided by some municipalities insure the neat appearance of collectors at all times. Information concerning the collection department should be furnished to the crews so that they can answer questions asked by householders. Collection personnel represent the local government and should be careful, efficient, and courteous at all times.

Adequate pay and favorable working conditions for collection personnel will aid in recruitment of more responsible individuals, will result in better service, and will reduce absenteeism and turnover of personnel in the department responsible for collection.

One incentive used by numerous cities to attract and retain personnel is the "task system." Under this system each truck and crew has a given route to cover each day, with the number of pickups and the distance covered considered to represent a reasonable day's work. When the route has been covered, the truck and crew return to the garage. If no complaints from the route are outstanding, the crew is free to leave. If there are complaints, such as failure to collect from one or more properties, they must be satisfied. The men are paid for an 8 hour day whether they have worked 8 hours or not. When properly controlled, this system has some advantages. It discourages loitering and improves the employees attitude in that he is pleased to be able to "get off" an hour or so early. However, without adequate controls, the system encourages haste, which frequently results in spillage, skips, and careless handling and damage to the containers.

REFUSE DISPOSAL

Introduction

Disposal is normally the final operation in the handling of refuse. Although performed last, in the organization of an integrated handling system it must be planned first since it has an important influence on both storage and collection.

The disposal of refuse is probably the most neglected phase of the total refuse handling system. There are many towns where storage and collection are reasonably good but where disposal is far from sanitary. Seven hundred ninety-six, or 69 percent, of the 1,149 communities reporting in the Public Health Service inventory *(27)* were using the open-dump method of disposal. Most open dumps at the edge of a community are found to be smoky, foul-smelling, rat-infested, fly-breeding centers from which rats and flies migrate into the community, with small containers that catch and hold water providing a habitat for mosquito development. Furthermore, the hog farm that practices garbage feeding often proves to be a malodorous and very productive source of vermin. Under these circumstances, the best storage and collection practices are nullified to a considerable degree.

Regardless of how diligently the householder or businessman attempts to control flies on his prem-

ise, he stands little chance of reducing the fly population of a community to a control level when a nearby dump or insanitary hog farm is a prolific breeding ground. Records indicate that flies may travel in appreciable numbers from 1 to 4 miles from point of origin. However, according to Schoof and Siverly, 1954, *(41)* "The dispersion capacity of the *mass* population is expended within 0.5 to 2 miles . . . 1 mile is the recommended distance to which fly control operations should be extended outside most communities."

Several methods of refuse disposal are being widely used in this country. A few others are used on a small scale or have been abandoned. Unsatisfactory methods will be but briefly discussed while satisfactory sanitary disposal procedures are worthy of greater consideration.

Garbage Reduction

In 1918, garbage reduction, with the salvage of grease and tankage, was a method of disposal in 24 cities with populations of over 90,000. The number was reduced to 7 plants in 1942 and 2 in 1952. There are a number of reasons why this method of garbage disposal has all but gone out of existence including the high initial cost and maintenance costs, the problem of odors, and the lack of a good stable market for grease and tankage.

Dumping in Water

This method has had considerable use in the past, especially by coastal cities, but on the whole has been abandoned. Dumping at sea resulted in the littering of shore lines with garbage and rubbish and was vigorously opposed by resort cities, both as a health and accident hazard and a deterrent to the tourist trade. Some of the towns and cities located along streams and rivers have often established open dumps along the shores. This method contributes to the pollution of the stream with liquids leached from the site or with solid refuse washed downstream by flooding.

The Open Dump

Because it is so cheap and requires little planning, if any, the old-fashioned insanitary open-dump method of refuse disposal is too frequently found in our present-day society. Not only does the open dump offend the aesthetic sense and give off objectional smoke and odors, it also is a very important breeding place for rats and flies and may produce a considerable number of mosquitoes. These vermin are capable of carrying disease to man, and constitute a serious nuisance to residents of nearby areas.

Every effort should be made by communities and local health authorities to eliminate this health menace and eyesore and to replace it with a sanitary and practical method of disposal.

Burning on Premises

Low-temperature burning of combustible rubbish is frequently used as a method of disposal on the individual premise. Some commercial incinerators built into large apartment projects may operate fairly well. Generally, home or business burning that utilizes burning cages or discarded oil drums is unsatisfactory. Garbage intentionally or inadvertently placed in these containers is only charred in this process, creating odors and permitting considerable fly breeding in backyards. Small amounts of charred garbage may also maintain a light rat infestation. The container itself is unsightly, and the scorched denuded earth around it is frequently littered with cans and broken bottles that constitute an accident hazard to children playing in the area.

Gas-fired residential burners, usually installed inside homes, are frequently found in some sections of the country. These will burn rubbish and garbage without causing a fly or rodent problem but may produce some smoke and odor during operation. The smoke and odor which contribute to air pollution are frequently an undesirable feature of commonly used methods of home burning. Where air pollution is a factor, this practice should be discouraged even where no attempt is made to burn garbage. However, in rural areas where no nuisance will result, combustible refuse containing no garbage may be burned in outdoor installations without auxilliary fuel, and refuse-containing garbage may be disposed of in gas-fired home burners.

Hog Feeding

Feeding garbage to hogs is of considerable economic importance in some areas of the United States. Today this method is unacceptable to

public health and agricultural authorities unless the material is heat-treated and the establishment is maintained in a sanitary condition. The feeding of uncooked garbage is important in the transmission of trichinosis among swine and is thereby responsible for a greater incidence of human cases.

In the United States, surveys made in 1938 (Hall, M. C., 1938) *(26)* indicated that approximately 1 person out of 6, or 17 percent, probably harbored trichinae. In Canada, where garbage cooking has been practiced for a number of years, the degree of human infection is estimated at about 7 percent of the population (Poole, J. B., 1953) *(38)*.

In 1952, widespread outbreaks of vesicular exanthema,* a serious virus disease of hogs spread largely through the feeding of uncooked garbage, led to the enactment and enforcement of garbage treatment regulations in most States. In all, forty-six States have adopted such regulations.

These laws require the heating of garbage to a temperature of 212° F. for a period of 30 minutes. Well-designed equipment should be used for cooking the garbage, since some equipment, especially "home made" and improvised devices, does not always distribute heat equally throughout the mass. This results in "dead spots" which may remain below 212° for some time after other portions of the garbage have reached the required temperature. Heat treatment, when carried out properly for the control of the virus of vesicular exanthema, will also kill trichinae encysted in the tissues of pork scraps, as well as any fly eggs, larvae, or pupae that may be present.

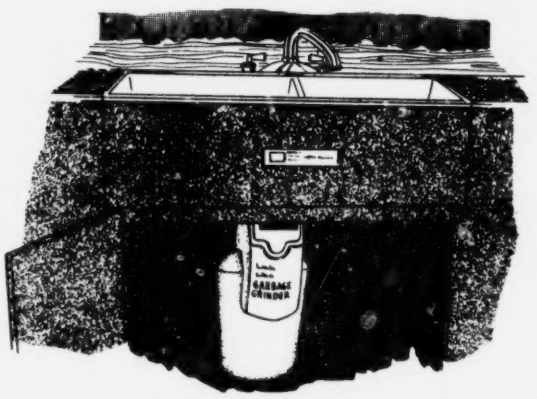
Hog farms where garbage feeding is practiced are often in such an insanitary condition as to allow much fly and rat breeding and some mosquito breeding. The odor originating from the typical insanitary hog farm is a decided nuisance to adjoining properties.

In order to control fly and rat breeding and, to a certain extent, the odor nuisance, several additional measures need to be taken. First, all feeding should be carried out on platforms constructed of acid-resistant concrete, brick with asphalt filler, or other impervious, easily washable materials. These platforms should be equipped with splash curbs and drains. All uneaten garbage, together with hog excrement on the platforms and in the pen area, should be removed after each feeding and disposed of by burying, incineration, or composting. The feeding platforms should be washed with water under pressure after removal of the uneaten residue and the liquid conveyed by drains to a septic tank, tile-field disposal system, a leaching pit, or a sanitary sewer. When done thoroughly, dry cleaning of feeding platforms may be satisfactory. Inedible objects that may be contained in the garbage, such as cans, bottles, and crockery, should be disposed of in a manner that will not provide rat harborage or permit mosquito breeding.

All material offering rat harborage should be removed or stored in an orderly manner on racks at least 12 inches off the floor or ground. Grains and feed should be stored in ratproof bins. If all these sanitary precautions are taken, there can be no serious public health objections to feeding garbage to hogs.

Grinding

An excellent method of garbage disposal for homes and for restaurants and some other businesses is by grinding it and discharging it into a sanitary sewer. A few cities have used strategically located central grinding stations for disposal of this type of waste, flushing the ground material into the city sewer or directly into the sewage treatment plant. However, this method of disposal does not eliminate the need for adequate premise storage of garbage and its frequent collection, nor for satisfactory storage and removal of rubbish.



*Bankowski, R. A. 1954. Vesicular Exanthema in the United States — Some Epidemiologic Aspects of the Disease. American Journal of Public Health. 44(9): 1119-1123.

Under certain conditions, disposal of garbage through the sewage treatment plant may be advantageous to its operation by increasing gas production (Johnson, Gerald, 1955). *(28)* However, garbage grinding, either at homes on a large scale or at a central grinding station, requires that certain of the sewage treatment plant facilities (e.g., digestion and drying) be of greater capacity than would ordinarily be required. When garbage from the home grinder is conveyed to a private sewage system, the capacity of the septic tank needs to be increased by about 50 percent.

Composting

Garbage composting is a biological process in which the material is usually shredded or ground and processed under anaerobic and/or aerobic conditions. Old World methods make use of anaerobic processes initially, followed by aerobic stages. The completely aerobic process, generally recognized as superior, generates temperatures of approximately 160° F. This heat accelerates fermentation, reduces dangers from pathogenic organisms, and makes the mass unattractive to vermin. Control of moisture content, oxygen, pH, and temperature is important to the efficiency of the process.

"In the modern sense, composting might be defined as a process in which under suitable environmental conditions facultative aerobic microorganisms, principally thermophilic, break down organic matter to a fairly stable humus" (Reclamation of Municipal Refuse by Composting, 1953). *(51)*

Composting has been in use in Europe and Asia for many years, but in the United States its use has been largely experimental. A number of projects have been started on a commercial scale, but for numerous reasons most have been discontinued.

In the past few years renewed interest in this method of refuse disposal has resulted in increased research on the subject. However, further study and experimentation are necessary to determine the most efficient and practical methods for composting municipal refuse without creating conditions favorable to flies and rats and to determine the economic feasibility of producing compost for use as a soil builder.

NOTE: Since the Sanitary Landfill and the Incinerator are two of the more acceptable and satisfactory methods of refuse disposal, their planning and operation are described here in detail.

THE SANITARY LANDFILL

Introduction

The sanitary landfill is an effective, proven method for the permanent disposal of refuse. It has been used in this country since about 1915, but has become a major method of disposal only since the late 1930's.

The sanitary landfill method can be used in any community where sufficient suitable land is available. It is especially suited for cities of less than 100,000 population because sufficient land is more likely to be available in these areas. Basically, this method of disposal consists of the following four steps:

1. Depositing the refuse in a planned, controlled manner.
2. Spreading and compacting it in thin layers to reduce its volume.
3. Covering the material with a layer of earth.
4. Compacting the earth cover.

Preliminary Considerations

Site Selection. The choice of a disposal site should be governed largely by the proximity to the source of refuse and by such factors as the availability of suitable land, access roads, and bridges. This consideration usually determines whether or not the sanitary landfill method of refuse disposal can be used economically.

1. Land must be available at reasonable cost and in sufficient acreage.
2. It must be located so that hauling distances are not too great. It may be located close to residential areas.
3. The most desirable landfill soils are sandy loams. However, where ideal soils are not available, operational procedures may be adjusted to local conditions. When suitability of the soil is in question, samples should be collected by borings and should be analyzed to determine the composition. Locations having solid rock formations close to the surface or with large boulders should be avoided.
4. Access roads and bridges must be capable of supporting loaded trucks. Stabilized or hard surface roads are especially important during wet weather operations.

5. Fills must not be located so as to obstruct natural drainage channels.
6. Locations where springs exist should ordinarily be avoided.
7. Sanitary landfills should not be located in areas subject to flooding unless measures are taken to prevent erosion of the fill, such as the erection of protective dikes.
8. Care should be taken not to locate landfills in areas where a normal or a raised water table during rainy seasons might result in pollution of public or private water supplies, or where the presence of creviced limestone might lead to underground pollution.

Land Requirements and Length of Haul. In estimating acreage requirements, experience indicates that about one acre of new land will be needed per year per 10,000 population (based on a 6-foot depth of compacted refuse). However, this has been found to vary from ¾ to 1½ acres and even higher depending on local conditions such as methods of operation, ratio of industry to homes, and type of refuse that the city collects. A city may often find it desirable to fill in relatively small low areas in various sections of town, moving from one to the other over a period of several years before beginning operations on a larger tract.

The expense involved in acquiring a suitable tract for a landfill operation will vary greatly. Many communities have operated for years by filling otherwise useless land at the request of, or with the permission of, the land owner, at no cost to the city. The land owners were in turn benefited by the increased value of their property. Other communities have had to pay many hundreds of dollars an acre for their landfill sites and still believe that, despite the relatively high cost of the property, the landfill method is the most economical method.

According to studies by the University of California, on California landfill practices *(49)*, a round trip of from 15 to 30 miles is apparently the maximum distance of haul before a centrally located incinerator becomes more economical. The capacity of the collection vehicles in use would be one factor that would help determine the length of haul that would be practical. For example, a town using 15 cu. yd. compactor-type trucks might find a 20-mile round trip excessive, but if the same town used 20 cu. yd. collection vehicles, a round trip of 20 miles might be economically feasible.

Other factors which may influence the feasible length of haul include possible use of transfer stations for refuse, traffic congestion, and political problems of metropolitan areas.

When the cost of the land and/or the length of haul required to reach the site approaches a certain point, which would vary with local conditions, consideration should be given to other satisfactory methods of refuse disposal.

Equipment. Equipment needs will be governed largely by the size of the community served and the nature of the site selected for the landfill. In some communities, the selection of equipment will be influenced by secondary considerations such as loading of earth, sand, or gravel on trucks, snow removal, and street maintenance. The following mechanical equipment combinations are suitable for various types of operation:

1. *Crawler tractor* with blade or shovel-type attachment.
2. *Bulldozer, Dragline combinations* (needed only for large operations or where operating in swamp or marsh).
3. *Carry-all scrapers and bulldozers* (for large operations or where earth must be moved a considerable distance).
4. *Bulldozer and trucks* to haul cover material, plus loading equipment at the source of cover material.

Table 1 may be used as a guide to the approximate size of equipment needed for communities with populations up to 50,000.

For cities with populations greater than 50,000, the number and size of tractor units would be increased proportionally. In larger communities either one large landfill site or several scattered disposal areas will be used. If the first condition exists, larger, more powerful equipment would be desirable. If the latter condition exists, several smaller units would probably be utilized.

Personnel. For a sanitary landfill serving less than 10,000 persons, the equipment operator would usually be the only person employed at the site. In addition to operating the equipment, he would direct the unloading of trucks, maintain the orderly appearance of the area, and keep the tractor in good operating condition. Although care should be taken to avoid accidents at any landfill, extreme care should be taken at landfills operated by one person for here no other individual would be present at certain times of the day to render aid or go for help.

Where the size of the population served does not

Table 1. Guide to the Approximate Size of Equipment Needed for Communities in Various Population Ranges

Population Served	Size of Equipment
Up to 10,000	One crawler tractor with bucket or shovel capacity of about 1 cu. yd.*
10,000 – 30,000	One crawler tractor with bucket or shovel capacity of about 2 cu. yds.*
30,000 – 50,000	One crawler tractor with bucket or shovel capacity of about 3 cu. yds.*

* Reference to buckets or shovels of varying capacities is not meant to imply that bulldozer blades may not be used. Many sanitary landfills are being operated in a very satisfactory manner with crawler tractors equipped with bulldozer blades.

require the full-time use of equipment and operator at the landfill site, both could be used on other community projects such as truck loading, snow removal, and street maintenance. The equipment operator for a small town might also be the driver of the refuse collection vehicle. If the equipment or the operator is sometimes used for other purposes, there should be a clear understanding that the sanitary landfill work comes first. Otherwise, the landfill may deteriorate into an open dump that will be a nuisance and a public health hazard.

On larger operations, it is desirable to employ a supervisor to direct all the activities of the project. He will supervise the unloading of trucks, the excavation of soil, the spreading, compacting, and covering of refuse, and keep the records. He should also be able to operate the tractor in the absence of the regular operator.

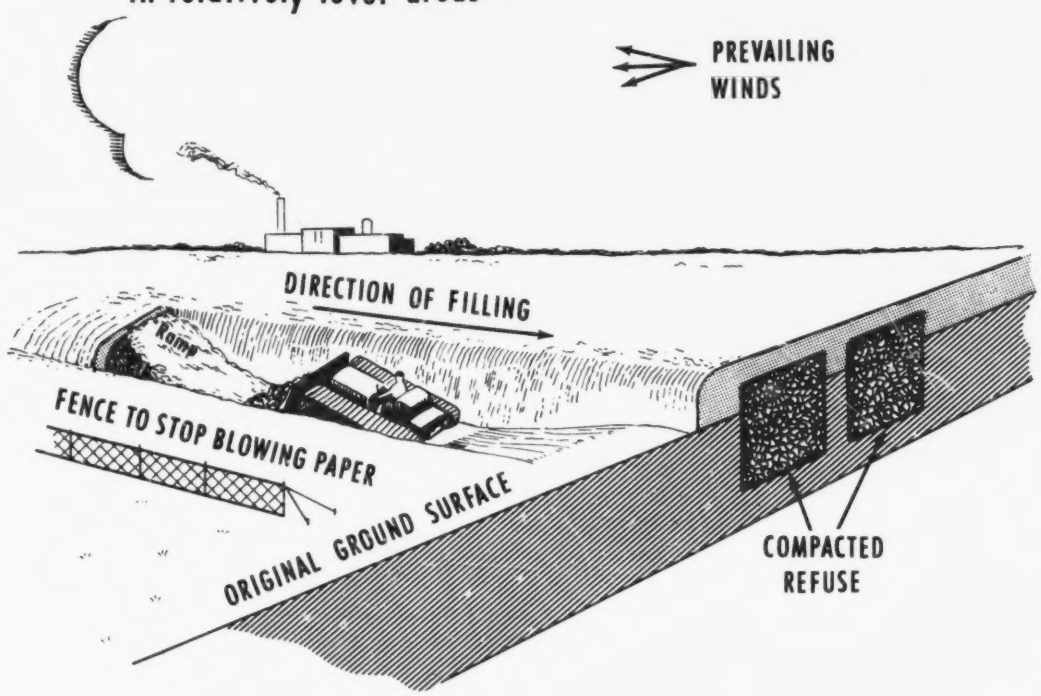
For efficient operation of any sanitary landfill, a capable equipment operator is essential. If the community employs a city engineer, he may give general supervision to the project. If the community, county, or other agency responsible for the operation of the landfill has no engineer, assistance is usually available from the State or local health department.

Operation

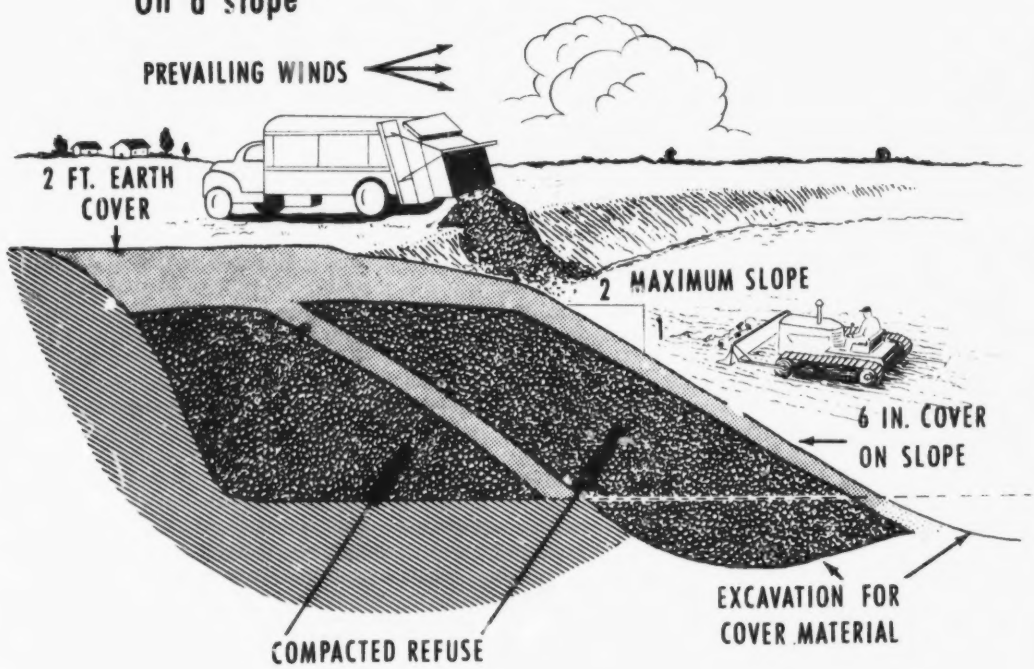
On Level Ground and Rolling Terrain. In relatively level areas a ramp may be constructed by making a shallow excavation and using the excavated earth to form that part of the ramp that is above the original ground level. On rolling terrain the operation may be started using a natural slope. The width and length of the slope will depend in part on the nature of the terrain, the volume of refuse delivered daily to the site, and the number of trucks likely to be present for unloading at the same time. The minimum width of the slope should be approximately twice the width of the tractor, which will allow the tractor to move from side to side and compact all of the refuse. The slope of the ramp should not be greater than 30°.

The refuse should be deposited at the base or at the top of the ramp by the collection vehicles, spread in 12-inch layers on the ramp by the tractor, and compacted. This should be done many times each day to obtain best compaction, rather than attempting to spread and compact a large accumulation, many feet in depth, at one time. At the end of the day's operation, the compacted refuse on the

In relatively level areas



On a slope

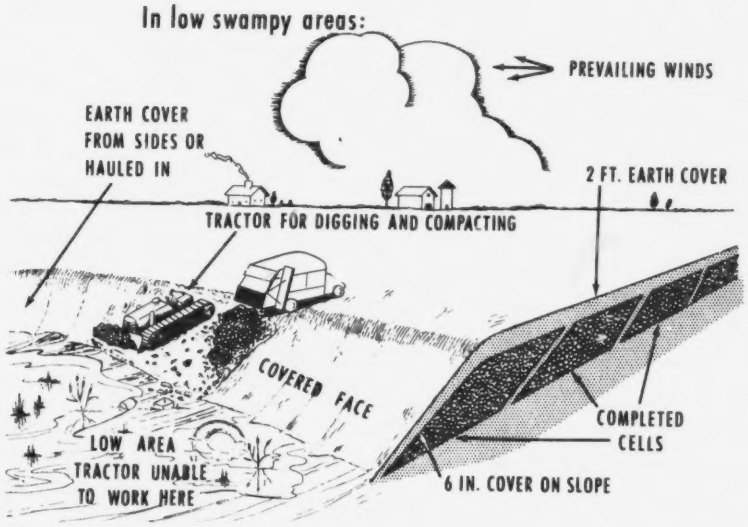


ramp is covered with earth taken from ahead of the base of the ramp. The following day's refuse will be spread and compacted on the slope formed by the covering over of the first day's refuse, and covered by further excavation in front of the base of the advancing slope. A windrow of earth built before placement of refuse along one or both edges of that part of the slope that is above original ground level is frequently desirable. This will lessen the scattering of paper and boxes by the wind, and will help to contain the working area and to facilitate covering of the side slopes. Earth placed as cover on the ramp should be at least 6 inches in depth after compaction, and the cover at the final level should be 2 feet thick.

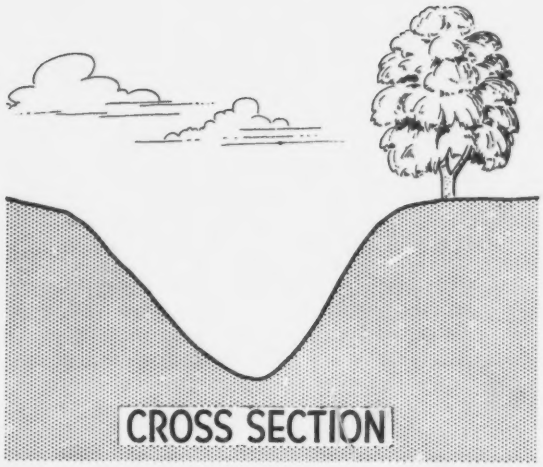
In Swamps, Marshes, and Low Areas. The same basic method may be used in most of the locations where it is impossible or undesirable to obtain cover material from the base of the slope. In low or swampy locations, a moving slope may be built into the area to be filled, working out from a natural bank or a constructed ramp. Here the refuse will necessarily be deposited at the top of the ramp. The slope should be gradual enough to allow the tractor to spread and compact the refuse over its entire surface. Frequently a foundation of waste building material or other material is first constructed into the swamp or marsh. On this foundation, the working slope is then advanced to fill the area to the desired level. Earth for cover is obtained from nearby elevations or is brought in by truck. In some situations, cover is obtained from in front of the working slope by use of a dragline. Thus a low area may be raised as shown.

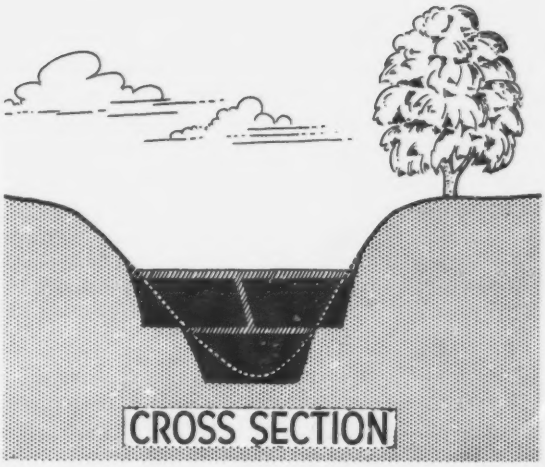
In Valleys and Ravines. Valleys and ravines are frequently chosen as landfill sites. When these are of considerable depth, they should be filled in layers with each layer beginning at the higher end of the ravine so that the natural drainage will not be obstructed. Earth cover for the first layer, as it moves through the length of the ravine, may often be obtained from ahead of the base of the advancing slope. However, cover for subsequent layers or "lifts" will usually be obtained from the sides of the ravine.

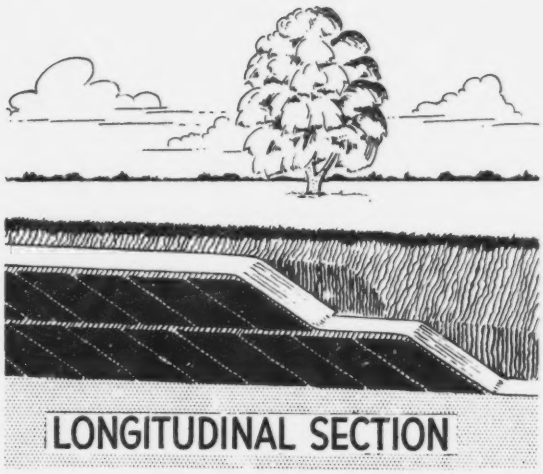
Under some circumstances it may not be desirable to extend the first layer of cells through the whole length of the ravine before construction of the upper layers is begun. In this event, the first layer of cells may be constructed only a relatively short distance from the upper end of the ravine. In longitudinal section this would give the appearance of a series of steps when the top layers are completed. This procedure would permit a portion of the cover for the upper layers to be obtained, if necessary, from the bottom of the ravine ahead of the face of the first layer; then brought up the ramps of the other layers to the operating level. When the upper layers have been completed, the bottom layer can be extended a short distance and successive layers built over it in the same manner. One advantage of this method of operation in ravines is the

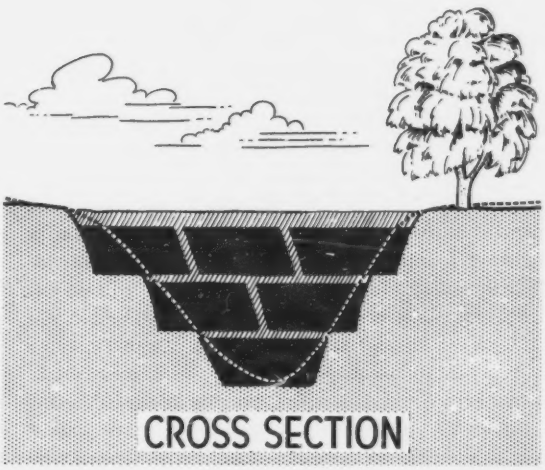

In low swampy areas:
PREVAILING WINDS
EARTH COVER FROM SIDES OR HAULED IN
2 FT. EARTH COVER
TRACTOR FOR DIGGING AND COMPACTING
COVERED FACE
COMPLETED CELLS
LOW AREA TRACTOR UNABLE TO WORK HERE
6 IN. COVER ON SLOPE

In Valleys and Ravines









reduction in exposure of layer surfaces to erosion.

Regardless of the manner of filling ravines, the depth of each layer of cells should usually be limited to 6 to 8 feet; and maximum compaction of refuse and cover should be obtained.

Small Community Operation. Some small communities may be financially unable to obtain new equipment heavy enough to carry on all phases of landfill operation. Some have purchased used tractors to solve this problem. Others have realized sanitary disposal of refuse by renting heavy equipment and having a trench excavated long enough to permit operation for 3 to 6 months. In the latter instance, a light-weight, relatively inexpensive tractor is obtained and used to spread and compact the refuse. Cover stockpiled during the excavation of the trench is applied to the compacted refuse by the light tractor. In some soils where excavation for cover is not too difficult or time consuming, the lighter equipment could accomplish the complete operation of a sanitary landfill for a small town. Experience indicates that heavier equipment should be obtained if possible, for maintenance costs on very light equipment may be high.

Winter and Inclement Weather Operations. Winter months do not prohibit successful sanitary landfill operation. Landfills have been operated successfully in an area where temperatures as low as 44° below zero are encountered and with winds as high as 30 m.p.h. The necessary trenches should be dug well in advance of extreme cold weather and cover material stockpiled for use at that time. In some soils it may not be necessary to excavate in advance; and even though very low temperatures prevail, excavation for cover may be accomplished on a day-to-day basis.

In sections of the country where winter temperatures are not severe, the bulk of the annual rainfall may come during this season. Areas near the stabilized entrance roadway should be reserved for operations during this or any other wet season or for short wet periods during normally dry seasons. If trenches are dug in advance to meet this possibility, adequate drainage should be provided. When the weather is favorable, operations may be carried on in areas somewhat remote from the entrance road or the stabilized roads through the disposal tract. A stand-by supply of cinders, shell, or gravel should always be present for use in emergency situations. Loads of street sweepings, ashes, etc., delivered to the fill should be saved for this purpose also.

Recommended Operating Practices

1. A sanitary landfill should be well planned, and its operation and maintenance should be performed by a trained person. The health department should have the authority to assure, by working through proper channels, that operations meet public health requirements at all times.
2. The municipal department responsible for operation should determine local sources of equipment for short-term use in the event of breakdown or major overhaul.
3. The face of the working fill should be kept as narrow as is consistent with proper operation of trucks and equipment so that the area of waste material exposed during the operating day will be minimal. The refuse should receive as much compaction as possible. This will facilitate the application of a solid, even layer of earth cover and minimize settlement.
4. The exposed refuse should be covered with earth as promptly as is consistent with proper operation, but certainly by the close of each day's operation, so that each day's deposit makes a closed cell. Earth cover should be thoroughly compacted to prevent newly emerged flies from working their way from the compacted refuse through to the surface.
5. The final covering for surface and side slopes should be maintained at a depth of approximately 24 inches.
6. The final level of the fill should provide a 0.5 percent to 1 percent slope to allow for adequate drainage. Much steeper slopes should be avoided as they encourage erosion. In case the finished fill has a boundary and/or side slope, it should be as gradual as possible to prevent erosion. These slopes should be seeded promptly and covered with straw to minimize erosion until vegetation becomes established.
7. If water under pressure is available, the exposed waste material and adjacent surfaces may be watered when necessary to allay dust. This additional moisture will also facilitate compaction and possibly will increase the rate of decomposition.
8. As a rule, the layer of refuse should not exceed an average depth of about 6 to 8 feet after compacting. Where successive "lifts"

are necessary, special attention should be given to obtaining good compaction so that subsequent layers may be constructed almost immediately with a minimum of settlement.

9. Control of wind-blown paper should be adequately maintained. This can be accomplished by the use of movable fencing such as snow fencing or portable chicken-wire fences, and also by careful location of the fill in favorable terrain.
10. Inspection for and control of insects and rodents should be carried on until fills are stabilized. All collections of surface water resulting from landfill operations should be drained, filled, or treated with effective chemicals so as to prevent mosquito production and allay disagreeable odors. Treatment with chemicals should be a temporary measure only, and efforts should be made to regrade the fill or take other permanent corrective measures as soon as possible.
11. After operations are completed, a maintenance program should continue until the fill has become stabilized. This should include prompt repair of cracks, depressions, and erosion of the surface and side slopes. Seeding of finished surfaces as soon as possible is highly desirable, for a good stand of grass will decrease erosion, improve appearance, and decrease surface cracking.
12. If scavengers are tolerated, they should be adequately supervised and not allowed to interfere with operations.
13. A separate area or trench may be provided for the disposal of such objects as tree stumps and large limbs.
14. A separate trench or pit may be desirable for the disposal of dead small animals, truck loads of spoiled foods, dead chickens, entrails, eggs, and large quantities of other putrescible materials, which should be covered immediately.
15. Generally, the rate of decomposition of refuse in a landfill precludes re-use of the same location for many years. In some areas little decomposition of materials has been observed even after a period of 10-15 years. However, New Orleans *(40)* is reported to have re-used a fill constructed in a former cypress swamp after a period of three years, without insect or odor nuisance. Moisture content in the fill area and local temperatures appear important in the rate of decomposition.

Accessory Facilities

In addition to equipment and personnel, certain facilities are needed, or are usually found desirable, at a sanitary landfill site. They include the following:

1. Shed or other shelter for equipment and personnel.
2. Rest room facilities.
3. Signs directing trucks.
4. Portable or semi-portable fencing.
5. Scales for weighing trucks (optional).
6. Hand sprayer for insecticide application.
7. Portable pump for removing accumulations of surface water.
8. Fire extinguishers and fire hydrant.

Advantages and Benefits of Sanitary Landfills

1. The sanitary landfill is often the most economical disposal system acceptable to health authorities, usually operating for one-third to one-half the cost of incineration.
2. The initial investment is low compared to that for other approved methods.
3. The landfill system is flexible; it can accommodate increases in population.
4. It may result in lower collection costs, since it permits combined collection of garbage and rubbish.
5. All types of refuse may be disposed of in the sanitary landfill.
6. The disposal site may be located close to or in populated areas, thus reducing the length of haul and the cost of collection.
7. Sub-marginal land can be reclaimed for future use, thereby benefiting the community. Completed landfills have been used for airports, parking lots, parks, playgrounds, and other recreational purposes.
8. Completed landfill areas may also be used for agricultural purposes.
9. The installation of any facility on reclaimed land should avoid, if possible, trenching into buried refuse. Should an area be used for recreation, buildings requiring footings

should be constructed just off the fill area. However, with proper engineering considerations, even heavy buildings may be constructed on completed fills.

10. Unsightliness, health hazards, and nuisances of open dumps are eliminated.
11. Sanitary landfills can be established quickly.
12. Several disposal sites may be used simultaneously at a relatively small additional cost.

Disadvantages of Sanitary Landfills

1. Suitable land at reasonable cost within economical hauling distance may not be readily available.
2. Improper construction may permit surface cracking and uneven settling, resulting in difficulty for trucks traveling on the surface in bad weather and giving an untidy appearance.
3. A landfill may settle from 10 to 25 percent depending on the degree of compaction, during the first 2 years, thereby requiring regrading and maintenance.
4. Fills generally present some difficulties for subsequent heavy construction.
5. If not properly located, seepage from fills into streams may increase stream pollution but may not show up for some time. This pollution is very difficult to alleviate.
6. Excavation in old fill areas may be objectionable because of obnoxious odors.
7. Problems in constructing buildings on former landfills are created, since methane, an explosive gas, is generated as decomposition proceeds.
8. Relatively large areas of land are required.
9. Decomposition of refuse in fills is slow in many areas.
10. An adequate supply of good earth cover may not be readily accessible.
11. The idea of the sanitary landfill often is difficult to sell because people think a sanitary landfill and a dump are synonymous.

INCINERATION

Incineration offers an excellent means of sanitary refuse disposal. The term incineration, as applied to the disposal of municipal waste, means the burning to ashes of all combustible portions of community refuse.

The newer incineration plants are architecturally pleasing, will handle mixed refuse containing both garbage and rubbish, and can be maintained in a clean and sanitary condition. Careful attention to design and operation has considerably reduced the atmospheric pollution that formerly resulted from incinerator operation.

The size of an incineration plant and its location within the town or city should be given careful consideration. Table 2 shows the suggested capacity of the incinerator according to the size of the population to be served. For purposes of economy, it should be located as near as possible to the center of the community. This will result in short haulage distances, more frequent round trips, and high collection vehicle productivity.

Incinerators should be designed to operate satisfactorily at all seasons of the year. Garbage that has received proper pre-storage handling and good storage at homes and businesses frequently contains about 70 percent moisture by weight. During the summer when fresh fruits and vegetables are abundant, this moisture content may be much higher. Rubbish, which consists mostly of combustible materials, has a lower moisture content. It is this rubbish in refuse that makes incineration practical by providing free fuel to reduce the refuse to a sanitary, easily handled, nuisance-free residue.

The Incineration Process

The elimination of the moisture content is the first of the three basic stages in the incineration process. Before refuse can be burned, it must be dry, so an efficient incineration plant must provide a way to eliminate the moisture from raw refuse. This is accomplished by having the "green" refuse placed at the back of the burning furnace or in a separate chamber, and from there it is moved to the actual burning area by mechanically operated grates or by hand stoking.

The actual burning of the combustible material, converting it into gases and leaving an inert residue or ash, is the second stage. A pre-heater may contribute greatly to plant efficiency by raising the temperature of the forced draft before its introduction into the furnace. Waste heat is frequently used for this purpose. This heated air for the forced draft helps the incinerator operate efficiently, particularly when the refuse contains an excessive amount of moisture. Gas or oil burners are sometimes included to provide the heat necessary to evaporate excessive moisture or to bring temperatures more quickly to the most effi-

cient range at the beginning of an operating day. The furnace should be designed to insure temperatures of at least 1250° F.

The conversion of any partially burned or odorous gases into a less objectionable state is the third stage in the incineration process. The burning of these gases usually occurs in the combustion chamber, which must be well designed to insure optimum velocity of gases and temperatures of at least 1400° F. This is a critical stage in incineration, as far as atmospheric contamination is concerned, for incomplete or faulty operation of this process is likely to result in excessive smoke and odors being emitted from the stack. To help meet the strict requirements of current air pollution regulations, additional facilities in the form of dust collectors, spray collectors, baffling, wet scrubbers, or other devices are frequently desirable.

Advantages and Benefits of Incineration

1. Incinerators may be located close to or in the center of refuse production areas, thereby minimizing haul distances.
2. Modern incinerators eliminate the need to collect garbage and rubbish separately, thus reducing collection costs.
3. Incinerators may be designed with capacities large enough for future population increases, or may be built so as to facilitate subsequent enlargement of plant capacity.
4. Incineration considerably reduces the volume of material for ultimate disposal. This residue may be used for filling in low areas or for local road construction.
5. Waste heat may be used for the drying of municipal sewage sludge, and this sludge may also be burned in incinerator plants.
6. In some modern incinerator plants, waste heat can be utilized to produce steam for generating electricity or for steam heating.
7. Some plants realize enough income from the sale of steam and scrap metal to pay operation costs.

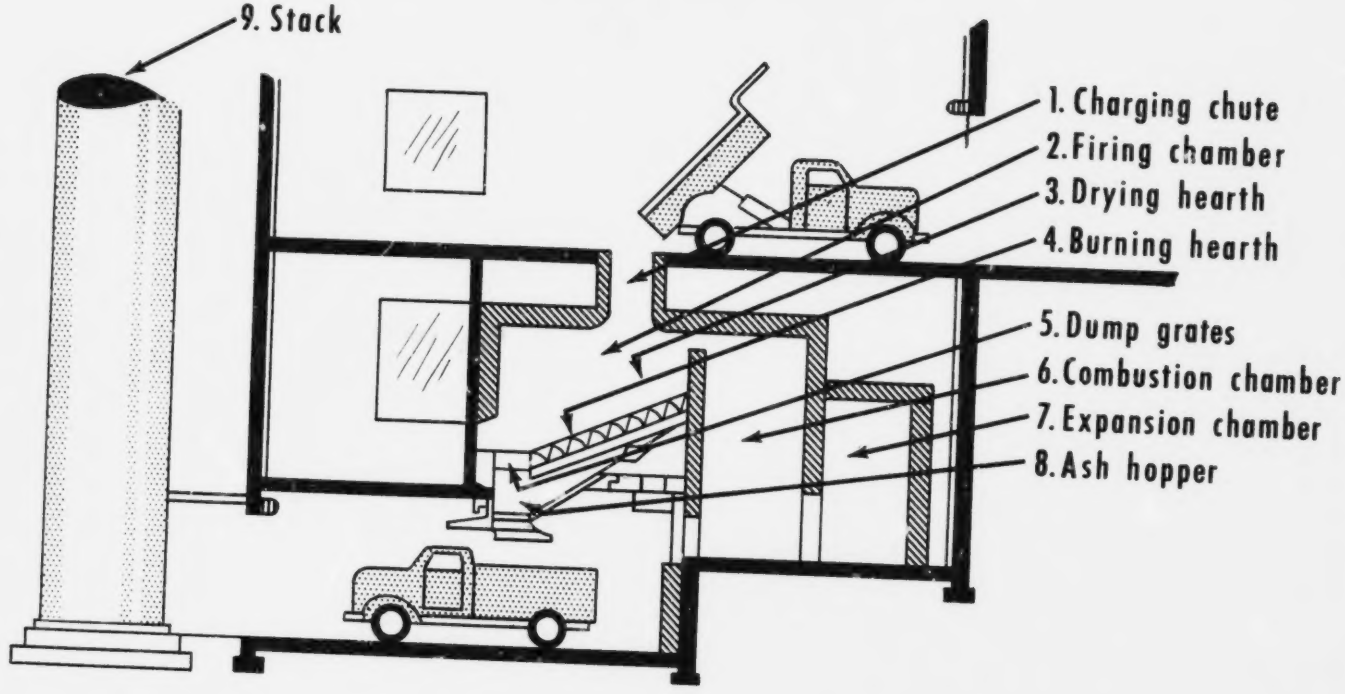
Well-designed and efficiently operated incinerators completely eliminate food for rats and breeding places for flies, which are available when insanitary methods of refuse disposal are used. In addition, smoke and odor nuisance is abated and the residue, when treated properly, offers no place for mosquito breeding or rat harborage.

Table 2. Suggested Incinerator Sizes

Population	Tons per Day*	Cubic Yards per Day**	Incinerator Capacity***
20,000	40	320	one unit @ 60 T in 8 hrs. †
50,000	100	800	two units @ 75 T per unit in 8 hrs. †
100,000	200	1,600	two units @ 150 T per unit in 8 hrs. †
500,000	1,000	8,000	four units @ 300 T per unit in 24 hrs. ††
1,000,000	2,000	16,000	two plants with four units each @ 300 T per unit in 24 hrs. ††

* Based on 4 lbs per day per capita — refuse, rubbish and garbage
** Based on 250 lbs per cu yd or 8 cu yds per ton
*** Suggested unit size allowing for growth and increased use of paper
† 50%
†† 20%

ONE OF SEVERAL TYPES OF INCINERATORS SUITABLE
FOR SMALLER CITIES*



* The addition of storage pit, crane, and feeding hopper would make a plant of this type suitable for larger cities also.

METHOD OF OPERATION

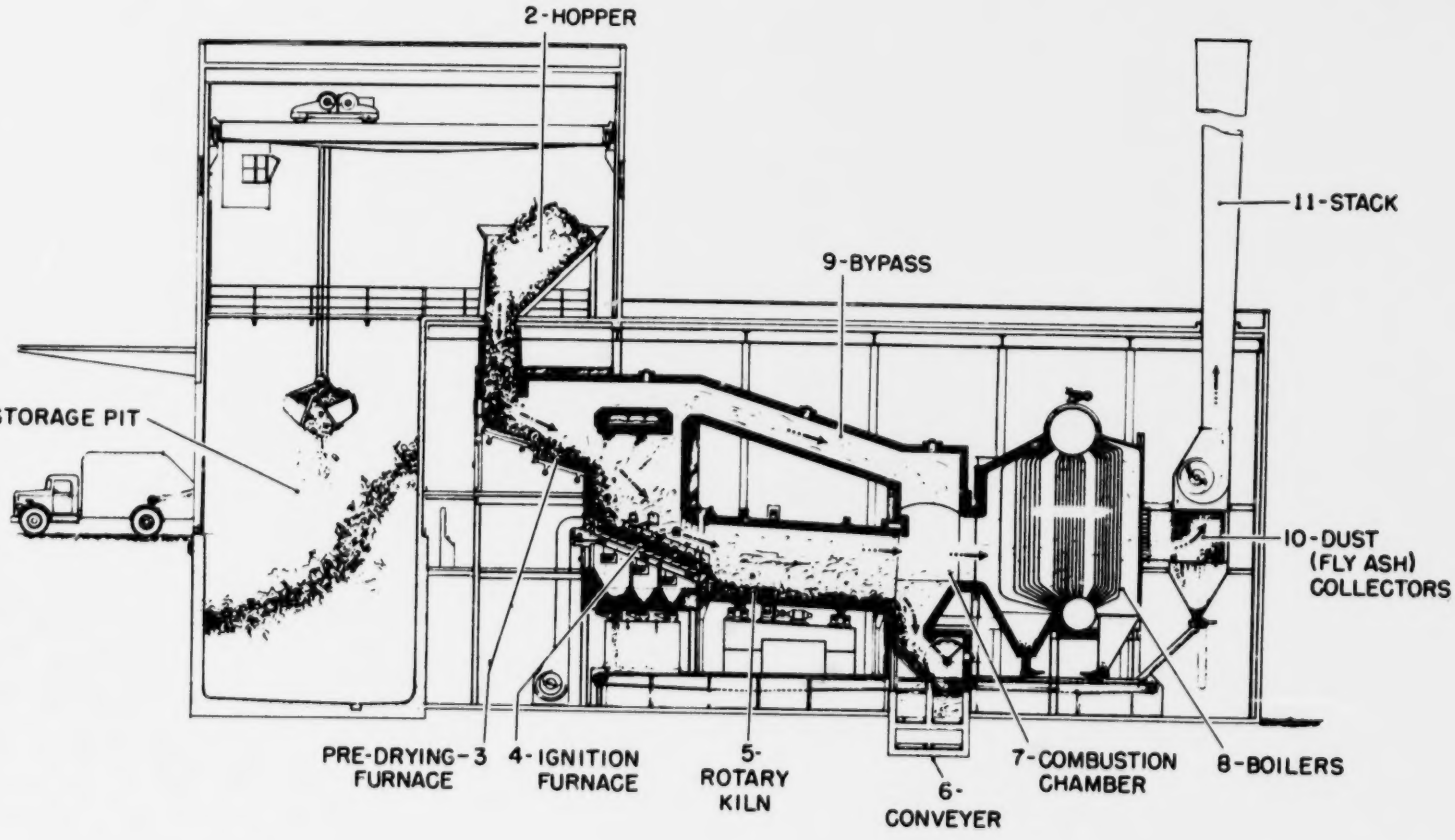
1. Refuse is delivered to the charging floor at intervals that preclude storage problems and is then fed into the charging chute (1). Workers may select and mix wet or dry refuse according to current furnace conditions.

2. The mixed refuse falls onto the portion of the firing chamber (2) referred to in the diagram as the drying hearth (3), where initial drying of the "green" refuse takes place. Mechanically-stoked grates provide regular agitation of the refuse and move it forward to that part of the hearth where the major portion of incineration takes place (4). A forced air blast applied directly under the grates is provided to increase the intensity of the fire.

3. The burned out residue (inert ash) and noncombustibles are finally deposited on the dumping grates (5). These hydraulically-powered grates are lowered as required, dumping the residue into the ash hopper below (8) from which it can be loaded periodically into trucks for removal.

4. Gases from the hearth pass into the combustion chamber (6) where the elimination of smoke and odor takes place and temperatures of at least 1400° F. are maintained, then through the expansion chamber (7) and on to the stack (9).

ONE OF SEVERAL TYPES OF INCINERATORS SUITABLE
FOR LARGER CITIES



METHOD OF OPERATION

1. Refuse is delivered into the storage pit (1) which affords flexibility and allows 24-hour operation although the bulk of the refuse is delivered during the day. The craneman may select and mix the refuse to create the best possible burning condition in the furnaces.

2. From the storage pit the refuse is hoisted by means of cranes and grab buckets to a hopper (2). From the dumping pit to the hopper the process is intermittent, but from the hopper to the final loading of ash on trucks it is continuous.

3. The hopper charges the predrying furnace (3) in which drying is effected by convection from the ignition furnace (4) below and ahead of the drying chamber. A portion of the hot gases from the ignition furnace rises and passes over the wet refuse and then is conducted by means of a separate duct, the by-pass (9), over the rotary kiln (5) to the combustion chamber (7).

4. The refuse then moves into the ignition furnace (4) by means of mechanically-operated grates, the speed of which can be varied. In the ignition furnace preheated air, under the control of the operator, is introduced beneath the fuel bed in four zones.

5. The ignition grates (4), operated mechanically, pass the partly-consumed refuse into the inclined rotary kiln (5), the speed of which can be varied to suit the needs of the burning material.

   The slowly cascading passage of the refuse through the kiln exposes the unburned material, thus completing incineration. The temperature in the lower end of the rotary kiln is usually about 1800° F.

   Hot gases from the kiln (5) pass into the combustion chamber (7). Here they unite with gases from the drying and ignition furnaces, and combustion of all flammable gases is completed before the remaining gases proceed to the boilers (8), then through the dust collectors (10), and up the stack (11).

6. Residue leaving the kiln falls onto a slowly-moving drag conveyor (6, which is submerged in water; thus the material is thoroughly quenched as it is carried outside. The ash is separated from the cans and metal, dropping through a rotary screen into bulk storage containers on tracks. The remaining metal is conveyed to a crusher and then to waiting railroad cars for shipment to steel mills.

REFUSE HANDLING IN THE SMALL COMMUNITY AND FRINGE AREAS

Many small towns and the fringe residential areas of our larger cities have no organized refuse collection service. Usually the service is available on an individual basis from private contractors, but coverage is incomplete, and disposal frequently is uncontrolled. The conditions that result are conducive to insect and rodent production.

Premise storage is often below average because of inadequate facilities and poor maintenance. Frequently there is no community organization to promote good refuse storage. Occasionally, the schedules of collectors are unreliable, with the result that storage facilities become overloaded. Consequently, fly breeding material and rat food and harborage are likely to be available in greater amounts than in towns and areas where local control of storage and collection is exercised, or in areas where populations are less concentrated.

Disposal is an especially troublesome problem in small towns and fringe areas. Persons not subscribing to private collection service dispose of their own refuse. Frequently the refuse is dumped along some back road, or even along a major highway, within flight range of the community for the flies that it will breed and within migration range for the rats which may become established. This litter provokes an adverse aesthetic response from travelers and responsible citizens.

The solution to this problem in small communities probably lies in activating public interest to promote better refuse handling, and in governmental regulation, if not actual participation.

A good example of how the problem may be satisfactorily solved is illustrated in highly populated fringe areas of a large eastern city. Here collection service is provided by the local Sanitary Commission, which also provides water and sewerage facilities. Adequate disposal is accomplished at one incinerator and several sanitary landfills. Some small adjacent sections in this area have private collection service, but the collectors are required to haul the refuse to approved disposal sites. Incorporated towns in the area that have their own collection service deliver their refuse to the Sanitary Commission's disposal facility that is nearest them and are billed monthly. Another adjoining county with few incorporated towns but numerous highly populated areas has refuse collection service provided by the county commissioners under contract. The contracts are contingent on the county health officer's approval of collection equipment and disposal method. Some counties have operated sanitary landfill disposal areas using equipment and personnel of the county highway department.

Numerous small towns have refuse collection service provided by a local contractor who serves on a part-time basis and uses his vehicle for other activities on non-collection days. The refuse is hauled to the nearest approved disposal site where it may be deposited for a small fee or for no fee at all. Some smaller towns may operate their own sanitary landfills. For their use, medium-weight equipment which is capable of carrying out all phases of landfill operation in a satisfactory manner is available at a cost that is not prohibitive. Good used equipment has frequently solved a small town's problem.

In some localities, two or three small adjacent communities have given one individual or company a contract to collect in their towns. Relatively long-term contracts to serve several towns might justify the contractor's purchasing compactor-type collection equipment. The towns may then locate a landfill site approximately equidistant between them and share the expense of acquisition and operation in proportion to the population served.

The problem of refuse handling in small communities and fringe areas may be resolved by determination and interest of citizen groups and officials devoted to the health and welfare of the community. There is much information available on the subject for guidance, and competent consultation may be obtained from State and local health department personnel. Experience, resourcefulness, originality, cooperation, and perseverance have solved similar problems for many communities.

OTHER SANITATION FACTORS IN THE CONTROL OF INSECTS AND RODENTS

Stored Products

One of the most important problems in commercial areas is rodent and insect infestation in warehouses and storerooms. Enormous quantities of food for human and animal consumption must be protected from this hazard. To do so is a tremendous task, but a number of sanitation techniques have been developed to help control infestations.

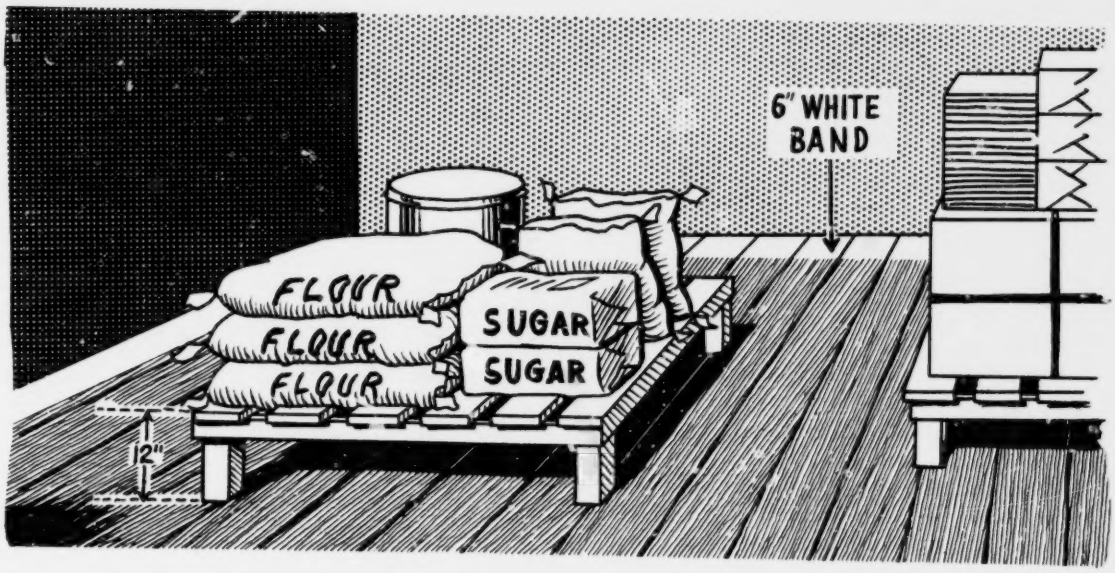
The use of wooden pallets which elevate the boxed or sacked materials 6 to 8 inches off the floor is a highly recommended sanitation technique. Their use also increases the speed and ease with which stored products can be handled with mechanical fork-lift trucks. In some storerooms, permanent racks 12 to 18 inches off the floor elevate stored food products. The open space beneath, if kept clean, discourages rat movement and allows for necessary periodic inspections. The stored materials should be stacked compactly, unless this creates a fire hazard, thus minimizing voids and reducing rat and mouse harborage. Material stored in warehouses and storerooms should not be stacked all the way to the ceiling. Instead, a space of at least 2 feet should be left to allow for adequate ventilation.

Aisles at least 2 feet wide should be provided along all walls, through the center of the warehouse, and elsewhere as necessary. A white band painted on the floor 18 inches out from all walls will serve as a reminder not to stack materials along the wall and will facilitate cleaning and inspection. If eradication measures become necessary, the method of stacking described here makes the operation less difficult, and in addition, makes the inventory of stocks easier.

Rotation of stored products is a practice that is most helpful in both insect and rodent control. The materials that have been in the warehouse the greatest period of time are shipped out first. This frequently does not allow sufficient time for them to become infested with stored product insects or for these insects to spread from older products to newly arrived materials. Moreover, new rodent infestations may be discovered earlier if rotation is practiced.

Spillage that results from damage to sacks and containers can accumulate in corners and along walls of warehouses. This provides easily accessible material for stored product insects, food for rats, and if it becomes moist, a breeding place for flies. Such spillage should be removed promptly. If the method of storage just described has been followed, cleanup will be much easier.

Warehouses and storerooms for food products should be of ratproof construction. Inside structural features that provide harborage for rats, such



as enclosed areas under stairs and under shelving, should be eliminated. Cracks in floors where insects may hide and where spilled materials would accumulate should be filled and sealed.

Food products that become contaminated by rodent feces or urine or damaged by gnawing should be destroyed or reprocessed for animal feed.

Although the measures described here may be supplemented by judicious use of insecticides, rodenticides, and fumigants, the sanitation principles set forth are basic for rat and insect control in storage areas. Maintaining warehouses and storerooms in a rat-free condition protects the public by preventing rodent contamination of foodstuffs and at the same time safeguards employees against on-the-job exposure to rodent-borne diseases.

Household and Premise Sanitation and Maintenance

Interior Premise Sanitation and Maintenance. The extent of rodent and insect infestation in and around homes and businesses may vary from only an occasional mouse, fly, or mosquito to heavy populations of rats, mice, cockroaches, flies, and mosquitoes.

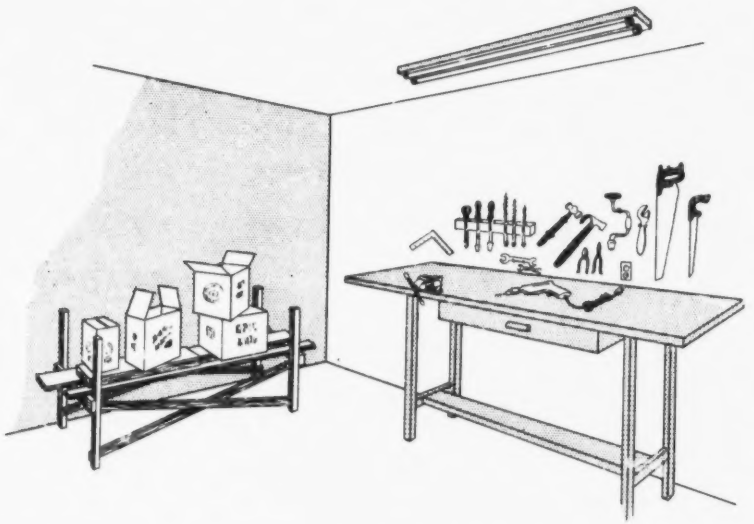
Once disinfestation has been achieved, interior sanitation and building maintenance will materially reduce the possibility of reinfestation. The housewife or restaurant operator must be regular in the practice of good housekeeping. Kitchen and dining areas should be cleaned daily to remove all crumbs, grease, and other material that might attract and support ants, cockroaches, and mice. Also, flies may breed in accumulations of grease, crumbs, and other materials in kitchens of restaurants. Good construction and maintenance of floors and walls in kitchens and in bakeries, with particular reference to elimination of cracks and other openings, as well as good arrangement of equipment, will do much to facilitate control of cockroaches. Refuse should be stored only in sound metal containers with tight-fitting lids, and the containers should be cleaned frequently. In homes, the metal refuse container with the self-closing lid and inner removable can provides good storage.

All foodstuffs normally purchased in bulk or boxes should be stored in metal or glass containers with tight fitting lids, especially where a rodent infestation exists.

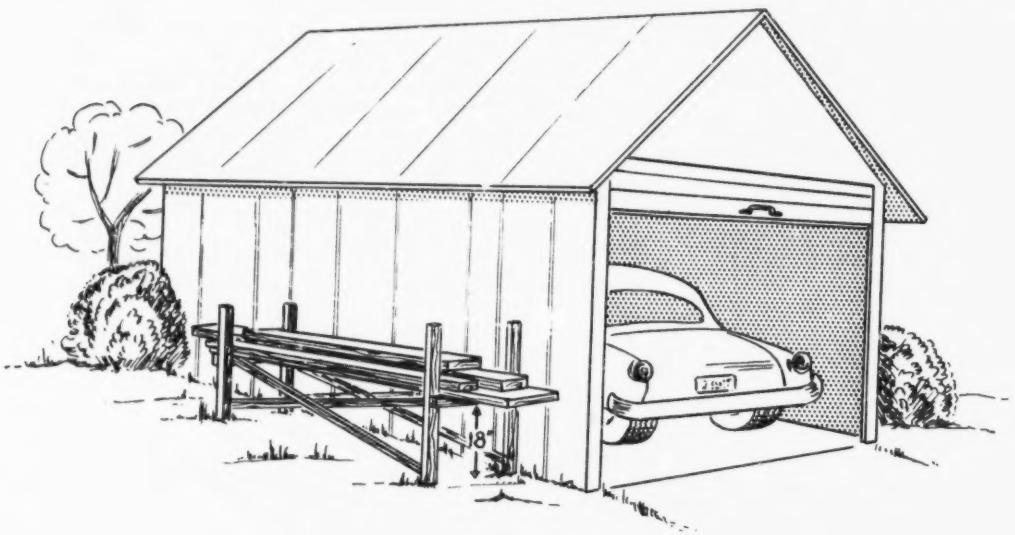
Old furniture, junk, and debris that accumulate in basements, attics, and storerooms should either be removed or stored in a manner that will eliminate rat harborage.

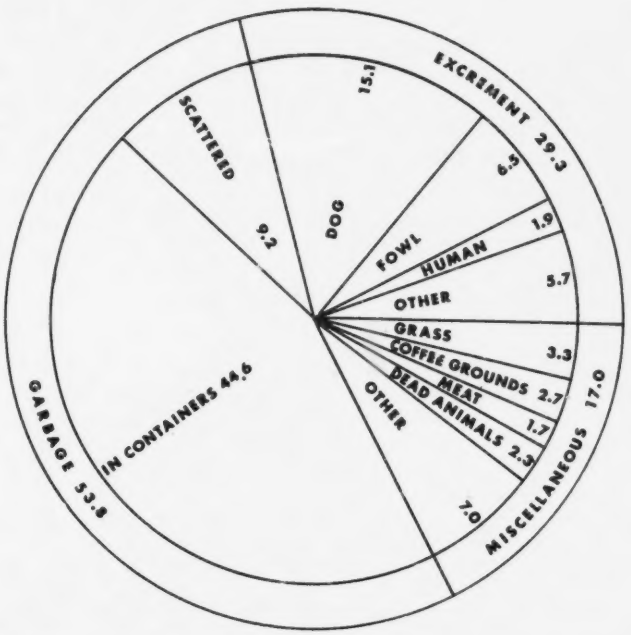
Concrete floored basements that occasionally become flooded may provide a breeding place for pest or disease-carrying mosquitoes. When flooding occurs, the water should be removed as soon as possible. If drains are present in basements, they should be kept cleaned out to prevent clogging and accumulation of water. In basements where drains are not provided, sump pumps are sometimes used. However, the small pits in which they are located will breed mosquitoes and should therefore be screened or treated regularly with chemicals. Adequate screening of basement windows and other windows in use might make screening or treatment of sump pits unnecessary. Occasionally, cisterns will be present, generally located in basements or under back porches. The tops and all inlets to these cisterns should be screened to prevent mosquito breeding.

Householders growing plants in water inside the home or on porches are frequently guilty of "raising mosquitoes." When plants are grown this way, water in the containers should be changed about every five days to prevent mosquito production. However, many of these plants will grow as well or better if the water is replaced with earth.

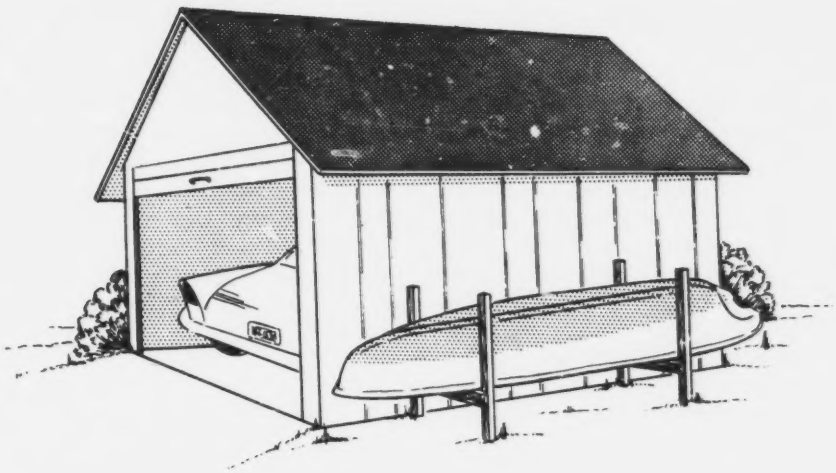


Exterior Premise Sanitation and Maintenance. This includes sanitary refuse storage and the storage of building materials and other objects on racks 18 inches off the ground to prevent rat harborage. Uneaten dog or cat food should be removed shortly after the pet has finished its meal. If such foodstuff is allowed to remain, it will provide food for rats and a breeding place for flies. Animal shelters should be kept clean, as accumulated droppings will provide a breeding media for flies and fleas. Dogs should be confined to the owner's premises. Their feces should be picked up from the lawn or yard daily, deposited in paper bags or wrapped in newspaper, and either placed in the refuse container or buried. In residential areas where dogs are numerous, a considerable portion of the fly population may be attributed to dog droppings. Shoof, Mail, and Savage (1954) *(42)* report that among fly-infested media, dog excrement was second only to garbage in Charleston, West Virginia, in 1952 and Topeka, Kansas, in 1950. In areas where stables for horses are maintained, manure should be cleaned up daily and properly disposed





Relative percentage of the various types of fly infested media. (665 samples.) Charleston, West Virginia - 1952



of or stored in tight metal containers until collected. Rabbit hutches and other animal pens contribute to the fly population unless they are cleaned frequently. Again, the droppings should be stored in tight containers until collected.

Any objects that might accumulate and hold water should be removed or inverted to prevent mosquito breeding. Water in bird baths should be changed twice weekly. Lily and fish ponds should be treated chemically or stocked with top minnows. Gutters along roofs of houses and other buildings should be kept free of leaves and twigs so that they drain completely. Underground drains for the removal of water from downspouts should not be allowed to clog.

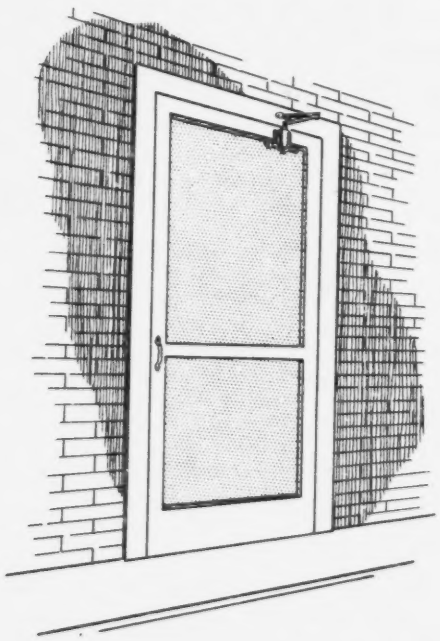
Catch basins of municipal storm sewers constitute an important source of mosquitoes in many urban areas. For example, many of the *Culex* mosquitoes thought to be involved in the transmission of the virus causing the outbreak of St. Louis Encephalitis in Louisville, Kentucky, in 1956 probably developed in the thousands of catch basins throughout the city. Where storm sewers and sanitary sewers are combined, catch basins with water traps at the inlets are needed to prevent the escape of obnoxious odors from the sewer. However, there appears to be little need for catch basins in inlets of separate storm sewers, especially in communities with well paved streets. The inlets to separate storm sewers may be constructed

in such a manner that no water will be retained, thus eliminating one source of mosquito breeding in the community.

Screening is still a very important measure for keeping flies and mosquitoes out of buildings. All windows, doors, and other openings should be adequately screened, and damaged screens should be promptly repaired. Where the use of screen doors is impractical, such as in some commercial establishments, fans over the doorway on the inside may create a current of air through which few flies will pass. When screen doors are used, they should be equipped with self-closing devices. The screening of outside water containers, such as rain barrels, will help prevent mosquito breeding.

Food processing plants in urban and rural areas should provide sanitary disposal of all putrescible waste. Improper handling of this material from canneries, abattoirs, and crab- and oyster-packing plants frequently contributes to high insect and rodent populations, which in turn endanger the health and welfare of workers and nearby residents and increase the possibility of contamination of the food products.

The practice of throwing bread and other foods outdoors for birds may create a rodent problem. Bird lovers should use hanging feeding cages or platforms.



All possible efforts should be made to eliminate the outdoor privy, which is generally the source of an appreciable portion of the fly population in a given area. Rat burrows are frequently found in the immediate vicinity of privies, too. Since flies have been proven to be important carriers of diarrhea-dysentery diseases, every effort should be made to extend sewers and to eliminate privies. If public sewers cannot be made available to a given area within a reasonable time, the use of septic tanks with absorption fields should be encouraged.

SANITATION AS RELATED TO INSECT AND RODENT CONTROL IN BUSINESS, INDUSTRIAL, AND INSTITUTIONAL ESTABLISHMENTS

Much of the material presented in the preceding sections has definite applications to business, industrial, and institutional establishments. However, certain types of establishments have characteristics that present sanitation problems related to insect and rodent control not found in other situations. Some examples of these are presented here.

Each category of industrial activity has its own insect and rodent problems. Most of these result from operational procedures and material-storage practices, building structure, equipment and its location, lack of maintenance, and improper housekeeping including inadequate storage and disposal of putrescible wastes.

Food processing plants frequently have infestations of rodents and insects whose presence leads to contamination or adulteration. In the control of insects, cleanliness of the whole plant is especially important. The floors, walls, and ceilings should be kept scrupulously clean. The processing machinery should receive special attention, since it often becomes heavily infested with insects when cleaning is inadequate.

The cleaning of the floors and walls may be difficult because of cracks, crevices, and small holes. These can hold food particles attractive to both insects and rodents and can also provide ways for insects to enter and leave rooms and buildings. The use of a caulking compound or other

similar materials to seal these small crevices and holes will facilitate cleaning, prevent entrance of insects, and reduce their harborage or breeding places.

Cleaning may also be hampered by inconvenient placement of equipment. Frequently equipment that cannot be moved is installed close to walls, and the space between, which therefore is seldom cleaned properly, may provide harborage for insects and rodents. Meters, fuse boxes, pipes, braces, and conduits installed on or near walls or floors provide many hiding places for insects and rodents.

Frequently, other conditions favoring insect and rodent infestation are found in food processing plants. These include false ceilings, poorly fitted doors and windows, boxed-in areas under counters and stairways, and improperly screened doors and windows. All of these conditions favorable to insect and rodent life can be eliminated by proper arrangement of equipment and storage of material and by minor structural alterations and good housekeeping and maintenance.

In the seafood industry, large piles of oyster, clam, and crab shells containing fragments of flesh provide an attractant and a breeding place for flies, as well as a source of food for rats. Oyster and clam shells should be collected twice weekly during the fly breeding season and either processed for industrial use or returned to the beds. Crab shells should be delivered to the fertilizer plant at least as frequently. It is important that cooling rooms and picking rooms in crab processing plants be ratproof and well-screened against flies.

The abattoirs, meat-packing plants and associated stockyards of the slaughtering industry are frequently troubled by rodent and insect infestations. The rats feed on inadequately protected and carelessly handled animal feed, and flies breed in large numbers in manure and in moist spilled feed. Correcting these conditions involves improvement of physical facilities. Easily cleaned concrete pen areas, with drains leading to sanitary sewers, should be provided. Feeding troughs should be so constructed that they are easily filled and cleaned. To reduce the rodent and insect problem, frequent cleanup of manure is required, with storage in fly-tight containers or prompt removal to a disposal site where it should be buried, burned, or spread thinly on fields as fertilizer.

Until such time as unwanted meat scraps and viscera from slaughter houses can be removed for proper disposal, they should be stored in a manner that makes them inaccessible to insects and rodents.

Hog farms, described in a previous section, dairy plants, and chicken farms are other animal industries that suffer vermin infestations as a result of human carelessness, poor arrangement of equipment, improper storage of materials, and inadequate disposal of wastes.

Other types of commercial enterprises may sometimes have severe insect and/or rodent infestations. In foundries, for instance, food for rodents is supplied where foundry flour, used to seal the top and bottom side of a mold to prevent the escape of molten metal at the parting line, is frequently allowed to fall to the floor where it becomes scattered around the area. Sometimes the new unused foundry flour is not stored in rodent-proof bins. Consequently, both stored and waste flour provide food for rats and a feeding place and breeding site for insects, especially grain beetles and other stored-food insects. Ample harborage for rats is often present in foundries in the form of improperly stored scrap, old flasks, bottom boards, and slip jackets.

Insect and rodent problems are common in the wood and paper product industries where poorly stacked log piles and wood chip piles offer abundant harborage, or where salvaged scrap paper and cardboard with food particles adhering offer an attraction for flies and rodents.

In flour mills and powdered-milk plants, it is important to vacuum-clean all overhead beams and other locations at frequent intervals to help reduce insect and rodent infestations.

A problem common to all industries, in fact any enterprise or office where people are employed, is the storage and disposal of lunch-time food scraps. Tight metal garbage cans should be provided in adequate numbers; and their use, in place of open waste containers, should be enforced. Otherwise, an infestation of rodents and insects, particularly of roaches, will be encouraged

Mosquito annoyance may be important in and around industrial plants. In addition to mosquito breeding places previously mentioned, these insects may breed in stagnant waters in cooling towers and settling basins, in waste waters from industrial processes including coal mines and oil fields, in lagoons, and in poorly drained areas around the plant. Many of these breeding sites can be eliminated by filling, draining, and alteration of construction or storage. Those breeding places that

cannot be eliminated or modified should be treated periodically with chemicals.

In hospitals, nursing homes, and other institutions, basic sanitation, again, is the answer to insect and rodent control. Cleanliness of the main kitchen, ward kitchens, and storeroom areas is especially important in control of cockroaches, rats and mice. Cleanliness of individual rooms and wards is also important. Refuse storage with adequate facilities and proper care and maintenance will do much toward fly, mosquito, and rodent control. The disposal of contaminated waste, dressinge, sputum, and similar materials is of cardinal importance, because insects and rodents can easily spread pathogenic organisms from these sources. Heavy galvanized metal containers with tight fitting lids, or heavy hard-rubber containers with screw-type locking lids, are satisfactory for storage of contaminated materials; but storage should be of very short duration. These materials should be disposed of at least twice daily by efficient incineration. All institutions producing biologically contaminated refuse should have well-designed incinerators using accessory fuel, which will insure destruction of pathogenic organisms and complete combustion of these wastes.

PROMOTING PUBLIC COOPERATION

General

Insect and rodent control may be effected in a community in two ways. It may be set up as an independent endeavor with its own staff and operating procedures, or it may be integrated with the existing environmental sanitation program. If established as an independent unit in a local health department, its activities must be coordinated with those of other local governmental units working in related fields. For example, local fire departments have given valuable assistance in improving refuse storage, especially in downtown business areas where improperly stored refuse frequently constituted a definite fire hazard. A vector control program, to be effective, must have the support of local officials, civic groups, and the residents and business men of the community.

Education and Information

Any successful program for raising the level of general sanitation depends on public awareness of the problem and its solutions, and the benefits that will accrue to the individual and the community. Consequently, a forceful, sustained, well-organized, informational phase is necessary to obtain full cooperation of the whole community. Without this public cooperation and without continued informational and promotional efforts by responsible authorities, a sanitation program for vector control will not receive an adequate start, nor will it be able to sustain sufficient interest to keep it going the year around.

One method for initiating such a program is to carry out a combination "Cleanup" and "Garbage Can" Campaign, or a "Paint Up, Cleanup, and Fix-Up" Campaign. Considerable enthusiasm can be generated by an activity of this nature, but it is especially important to take measures to avoid letdown after such efforts. Every means should be used to emphasize to the public that the campaign is just a symbol of an activity that should be practiced day after day, year after year. The informational program begun before the "Cleanup Week" should continue actively after the campaign closes.

Numerous devices have been used successfully to stimulate interest and participation. The mayor may officially declare a specified week as "Cleanup Week." Full use should be made of radio, newspapers, and other informational media to announce

Fly Control Program Begins

Health Department Sponsors Move to Reduce Fly Breeding in City

the campaign and to familiarize the citizens with its purposes and its benefits. Schedules of the days and hours when city vehicles and other collection vehicles will cover various sections of the city to collect junk, debris, and other useless items should be published in the newspapers and announced over radio and television.

Prior to the campaign, talks to civic groups, PTA's, and church groups should be made to enlist cooperation and active support both for the cleanup campaign and the program as a whole. An active civic-minded group composed of leading community citizens might make the support of the whole program one of its projects. This assistance would be welcomed by the responsible agencies, which frequently are short of personnel.

A good plan is for active civic groups to divide the city into districts, with one person responsible for each district. These district supervisors then appoint "block captains," residents of individual blocks, responsible to the district supervisor. The professional personnel of the local health department work with the district supervisors by aiding in the orientation, motivation, and instruction of the groups of block captains. One or more civic groups cooperating in this or a similar manner can help immeasurably in achieving the desired sanitation improvements. While coordinating the efforts of these voluntary workers during and after the "kick-off" campaign, the local health department carries on its own activities toward attaining its goals. Utilization of radio, television, newspaper articles with photographs, posters, and literature is an essential part of the local health department's permanent public relations program.

Other methods have been used with good results for alerting the public to the need for good premise sanitation and maintenance. Printed cards or instruction sheets covering refuse handling practices and containing excerpts from the city ordinance can be distributed to a large proportion of the town's residents by mailing them in the envelopes with city or county water or tax bills. These sheets or cards describe proper prestorage treatment of refuse and approved storage facilities, give collection schedules, and provide other useful information.

If enough health workers are available, their personal visits to individual premises to explain the program, to distribute the cards and other literature, and to answer questions will stimulate more public interest than can be developed by merely sending literature. Distribution of any literature could be accomplished through civic volunteer groups who have been properly oriented and briefed, as previously suggested. It might be desirable for volunteer groups such as the Boy Scouts to do this work in the residential areas, while the local sanitarians distribute the cards or other literature in the business districts during the course of their routine activities. Personal visits allow discussion of refuse handling techniques, and other conditions on the premise that may be conducive to rat and fly breeding and mosquito production may be pointed out.

GARBAGE COLLECTION REGULATIONS

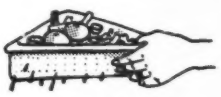
EFFECTIVE NOVEMBER 5, 1951

1. **GARBAGE COLLECTION** will be made **TWICE** weekly and will include **ALL** garbage, rubbish, and refuse which is placed at the curb in **APPROVED METAL CONTAINERS** at 8:00 A.M. on the scheduled date of collection. It **WILL NOT** include ashes, dirt, masonry, and large metal items.

2. **GARBAGE CANS** shall be water-tight, made of metal, fitted with handles and with tight-fitting covers. Cans shall not exceed twenty (20) gallon capacity and not more than six (6) cans will be permitted for each residence.

3. **COLLECTIONS** will be made between the hours of 8:00 A.M. and 5:00 P.M. All garbage must be at the curb at 8:00 A.M. and empty cans removed by night fall. No collection will be made on legal holidays. The next scheduled date will apply.

4. **WRAPPING GARBAGE** All wet garbage shall be wrapped in several thicknesses of paper. This will double the life of your garbage can and reduce the cost of incineration.



Drain

Wrap

ASH COLLECTION REGULATIONS

1. **ASH COLLECTION** will be made **ONCE** weekly and will include ashes, dirt, masonry, and large metal items, placed in water-tight metal cans fitted with handles and tight-fitting covers. Cans may be of ten (10) gallon or twenty (20) gallon size but in no case shall the total weight exceed 100 pounds. (10 Gallon of Ashes weigh about 100 pounds.)

2. **TREE LIMBS** will be accepted with ash collection and shall be tied in bundles that do not exceed four (4) feet in length.

GENERAL INFORMATION

1. **DETAILED REGULATIONS** covered by Ordinance # 669 are available at the Incinerator upon request.

2. **SPECIAL PROBLEMS** — For assistance with special garbage problems, please call **SUPERINTENDENT OF INCINERATOR, PHONE 4137.**

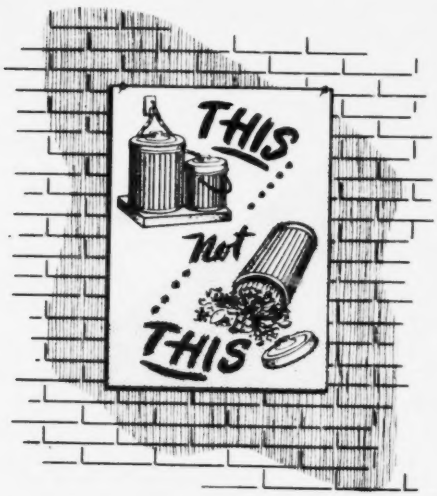
Meetings of civic groups can often be utilized for sanitation education. Program committees of these groups generally appreciate guest speakers. Parent-Teachers Associations, civic clubs, church groups, and service organizations welcome programs that demonstrate ways of attacking problems of general interest. With the various visual aids available on sanitation and the vector and pest problem in general, a very interesting and informative program can be presented at these meetings, and appropriate pamphlets and leaflets can be distributed.

School children, also, can be interested in sanitation projects. This can be done through assembly programs or art projects. Literature on breeding and control of flies, mosquitoes, cockroaches, and rats can be distributed to school assemblies and introduced by talks to these groups. Then by requesting the students to take the literature home with them, wide distribution can be achieved. In some cases, instruction in general sanitation and its effect on insect and rodent control has been given as an integrated part of hygiene, civics, general science, or general biology classes. Guest speakers whose talks are illustrated by movies or slides are welcomed by teachers as a change for the students and as an enrichment of the course or curriculum.

In conjunction with the teaching and promotion of sanitation, poster design contests have proven beneficial. Acceptable posters for use in subsequent portions or phases of the program can thus be produced. Frequently, local merchants may provide modest awards for the contest winners.

A form of public education which deals with only one phase of sanitation is the tagging of unsuitable refuse containers. The large tags usually used for this purpose inform the owner that his refuse storage is inadequate. In addition, they frequently carry a brief list of common deficiencies which may be checked to indicate specifically what action is required of the owner. Sufficient publicity to inform the public regarding the action to be taken should precede and accompany a tagging campaign. Good publicity is, in fact, an essential part of all phases of a sanitation improvement program. As the operation proceeds, the local newspapers could publish daily or weekly reports showing such data as number of premises surveyed, and number of premises with inadequate refuse storage. The work and record keeping could be carried out by the refuse collection agency, if

necessary. Subsequent checkups could also be reported to the people through newspapers, radio, and television, revealing the percentage of compliance in different sections of the city or town. For greatest impact, tagged containers which people continue to use should be collected and destroyed. Of course, legal basis for such action must be present in the code or ordinances of the area.



Date _____ Nº 1095

Location _____

Type Container _____

Condition _____

_____

_____

By _____

Nº 1095

City of Takoma Park

Official Notice

This container is unfit for use as a refuse container.

For Further Information Call

SLigo 6999

Date _____

Location _____

SANITATION DIVISION
CITY OF TAKOMA PARK

Per _____

Ordinances

Ordinances, especially those providing sufficient penalty for offenders, help insure public cooperation. The backbone of an effective sanitation program is an ordinance that gives the authority that is needed. However, a sanitation program should not rely on the city ordinances to accomplish its aims. The major portion of desired improvements should be attained through a well-planned, tactful, continuing educational program. The well-balanced information program will bring large segments of the population to realize the value of the benefits that will accrue to them, their families, and the community as a whole through their compliance with the requests for improved sanitation. There are, unfortunately, always a few stubborn or unreasonable persons in each community; and, to obtain compliance by this group, legal action generally is necessary.

SUMMARY

Environmental sanitation is a modification of environment in such a manner that a maximum of health, comfort, safety, and well-being accrues to man. Conversely, these same modifications tend to make the environment less favorable for the continued existence of insects and rodents.

Sanitation is a problem of the community as well as the individual. Continual disregard on the part of either will certainly result in unnecessary disease and annoyance. Frequently, individual effort is fruitless without public control. At the same time, efforts of public health agencies are doomed to failure without suppo of individual citizens.

Lack of understanding, carelessness, and indifference are largely responsible for all insanitary conditions. Therefore, a well-organized, forceful informational program is essential to the realization of good community housekeeping.

When the desired sanitation standards are attained, the community will have reduced the numbers of vectors and pests, the incidence of disease and annoyance, and will have become a much more pleasant place to live. Consequently, there will be greater attraction for new industry and desirable residents, more opportunity and disposition for work and relaxation, increased property values, and a greatly increased individual pride in home and community.

AUDIOVISUAL AIDS TO INSTRUCTION

Films

"Sanitary Storage and Collection of Refuse," . . . . . .MP-M-4 = CDC, Atlanta, Georgia.

"From Trash to Treasure" (on sanitary landfill). . . . . International Harvester Company and Drott Manufacturing Company.

"Sanitary Landfill" . . . . . .Allis Chalmers Manufacturing Company.

"Incineration" . . . . . CDC. Atlanta, Georgia. FG-352

"A Community Problem". . . . . .Caterpillar Tractor Company.

"Sanitary Landfill Up North". . . . . North Dakota State Department of Health, Bismark, N. D.

"Refuse Disposal by Sanitary Landfill" MP-M-228. . . . . .CDC, Atlanta, Georgia.

"Organized Mosquito Control," M = 191 . . . . . .Same.

"Constructing a Sanitary Pit Privy," MP = 4-083 . . . . . Same.

"Fly Control Through Basic Sanitation," MP - 4 - 090 . . . . . .Same.

"Biology of Domestic Flies," M-80. . . . . Same.

"Community Fly Control Operations," MP = 4-094. . . . . Same.

"Sanitation Techniques in Rat Control," MP = M37-1d. . . . . .Same.

"Rural Rat Control," MP = 4-116. . . . . .Same.

"Rat Proofing," MP = M37.1e . . . . . .Same.

Filmstrips

"*Aedes Aegypti* Survey Techniques," FS-290. . . . . .Same.

"Biology and Control of the Cockroach," - F91. . . . . Same.

"Biology of Domestic Flies" - F80. . . . . Same.

"Domestic Vector Control by Basic Sanitation" - SPF296 . . . . . Same.

"Sanitary Landfill, Part I, Operating Procedures" - F229a,. . . . . .Same.

"Sanitary Landfill, Part II, Small Community Landfills," - F229b,. . . . . Same.

"The Story of Sanitary Landfills". . . . . Caterpillar Tractor Company.

The films and filmstrips produced by the Communicable Disease Center are available on free, short-term loan within the United States. Requests should be addressed to:

The Communicable Disease Center, U. S. Public Health Service, Atlanta 22, Georgia

Please indicate exact dates that films are to be used and allow ample time for shipment.

REFERENCES

Textbooks

(1) American Public Works Association, 1958. Refuse collection practice. xvi + 562 pp., 190 figs.

(2) Ehlers, V. M., and Steele, E. W. 1950. Municipal and rural sanitation. McGraw – Hill, New York. xi + 548 pp., 147 figs.

(3) Fair, G. M., Geyer, J. C., and Morris, J. C. 1954. Water supply and waste disposal. John Wiley and Sons, Inc., New York. xi + 973 pp., 238 figs.

(4) Herms, W. B. 1950. Medical entomology. Macmillan Co., New York. xvi + 643 pp., 191 figs.

(5) Hopkins, E. S., and Schulze, W. H. 1954. The practice of sanitation. The Williams and Wilkins Co., Baltimore, Md. v + 466 pp., 131 figs.

(6) Matheson, R. 1950. Medical entomology. Comstock Pub. Co., Ithaca, N. Y. xi + 612 pp., 240 figs.

(7) Metcalf, C. L., Flint, P. W., and Metcalf, R. L. 1951. Destructive and useful insects. McGraw – Hill, New York. xjv + 1071 pp., 584 figs.

Periodical Articles and Pamphlets

(8) Allis Chalmers. Sanitary landfill, an important community benefit. Milwaukee, Wisc. 11 pp.

(9) American Public Health Association. 1960. The control of communicable diseases in man. APHA, New York. 9th ed. 219 pp.

(10) American Society of Civil Engineers. 1954. Garbage reduction. Proceedings, Report of Subcommittee, Vol. 80, Separate No. 498. 15 pp.

(11) Anderson, R. L. 1952. Fundamental requirements for a good sanitary landfill. Public Works, **83**(9): 74.

(12) Anonymous. 1955. Sanitary fill chases mosquitoes. The American City. **70**(12): 15.

(13) Anonymous. 1954. County highway department operates sanitary landfill. Public Works. **85**(9): 142.

(14) Anonymous. 1954. Report on the investigation of leaching of a sanitary landfill. State Water Pollution Control Board Pub. No. 10, Sacramento, Calif. 92 pp.

(15) Anonymous 1953. Sanitary landfill in a small city. Public Works. **84**(11): 125.

(16) Bjornson, B. F., and Wright, Charles V. 1960. Control of domestic rats and mice. U. S. Dept. of Health, Education, and Welfare, Public Health Service. U. S. Government Printing Office, Washington, D. C. 25 pp.

(17) Bjornson, B. F. 1953. Light track-type equipment shows usefulness in sanitary landfill operations. The American City. **68**(1): 92.

(18) Booth, E. J., and Bartholomew, N. 1954. Cold weather is no obstacle to fill-and-cover. The American City. **69**(16): 114.

(19) Caterpillar Tractor Co. Questions and answers about sanitary landfills. Peoria, Ill. 15 pp.

(20) Coffey, J. H., and Schoof, H. F. 1949. The control of domestic flies. FSA,* PHS, CDC, Atlanta, Ga. 34 pp.

(21) Coffey, J. H., and Dunn, W. L. 1951. The importance of sanitary refuse handling in fly control, FSA,* PHS, CDC Bulletin, Atlanta, Ga., April, 11-17.

(22) Dravo, Inc. 1956. Incineration. Bulletin No. 1506, Pittsburgh, Pa. 6 pp.

(23) Drott Mfg. Corp. How to construct a sanitary fill. Milwaukee, Wisc. 11 pp.

(24) Drott Mfg. Corp. Sanitary fill. Milwaukee, Wisc. 32 pp

(25) Eagle, G. H., and Overman, S. M. 1956. Good refuse sanitation is not impossible. Public Works. **87**(12): 83.

(26) Hall, M. C. 1938. Studies on trichinosis. VI. Public Health Reports. **53**(26): 1086-1105.

(27) Hope, Malcom C., Johnson, Chas. C., and Weaver, Leo. 1956. Refuse handling practices in the United States. Public Health Reports. **71**(2): 204-208.

(28) International Incinerators, Inc. 1957. International Incinerators, Atlanta, Ga. 20 pp.

(29) Johnson, Gerald. 1955. Ground garbage boosts sewage treatment. The American City. **70**(2): 97-99.

(30) Klassen, C. W. 1951. Sanitary fill standards. The American City. **66**(2): 104-105.

(31) Koetter, Eldon. 1956. How to plan a successful landfill. Public Works. **87**(11): 78-79.

(32) Korff, F. A. 1948. Food plant sanitation. Soap and Sanitary Chemicals. **24**: 139-141.

(33) Lancaster, R. 1954. More cropland for Kearney. The American City. **69**(8): 99-100.

(34) Los Angeles County, California. 1955. Planned refuse disposal. A report to the directors of the county sanitation districts. 117 pp.

(35) Moore, A. D. 1955. The effects of sanitary landfill on the ground water at Riverside. Western City. **31**(6).

(36) Ohio Department of Health. 1953. The refuse problem. 52 pp.

(37) Pittsburgh-Des Moines Steel Co. 1955. Incineration Plants. Bull. 601-55, Pittsburgh, Pa. 22 pp.

(38) Poole, J. B. 1953. The incidence of human trichinoses in Canada. Canadian Journal of Public Health. **44**(3824): 295-298.

(39) Rogus, C. A. 1955. Sanitary refuse fills in wet areas. Public Works. **8**(12): 65.

(40) Schneider, C. 1953. Sanitary fill re-used safely. The American City. **68**(4): 83-84.

(41) Schoof, H. F., and Siverly, R. E. 1954. Multiple release studies on the dispersion of *Musca domestica* at Phoenix, Arizona. Journal of Economic Entomology. **47**(5): 830-838.

(42) Schoof, H. F., Mail, G. A., and Savage, E. P. 1954. Fly production sources in urban communities. Journal of Economic Entomology. **47**(2): 245-253.

(43) Scudder, Harvey I. 1949. Some principles of fly control for the sanitarian. American Journal of Tropical Medicine. **29**(4): 609-623.

(44) Skornecka, J. E. 1955. Is sanitary landfill right for your community? Public Works. **1**(86): 90.

(45) Spencer, C. C. 1943. Recommended wartime refuse disposal practice. Public Health Reports. Supplement No. 173. 19 pp.

(46) U. S. Dept. of Health, Education, and Welfare, PHS, CDC, Technology Branch. 1956. Vector control through proper refuse storage, collection and disposal. Atlanta, Ga. 38 pp.

(47) U. S. Dept. of Health, Education, and Welfare, and American Public Works Ass'n. 1953. Refuse collection and disposal for the small community. 39 pp.

(48) U. S. Federal Security Agency,* Public Health Service, CDC, Training Branch. 1949. Ch. IV. Sanitation and rat control. Atlanta, Ga. 20 pp.

* Became U. S. Dept. of Health, Education, and Welfare in April 1953.

(49) University of California, Sanitary Engineering Project. 1952. An analysis of refuse collection and sanitary landfill disposal. Tech. Bull. No. 8, Series 37. 133 pp.

(50) University of California, Sanitary Engineering Project. 1950. Composting for the disposal of organic refuse. Tech. Bull. No. 1, Series 37. 42 pp.

(51) University of California, Sanitary Engineering Project. 1953. Reclamation of municipal refuse by composting. Tech. Bull. No. 9, Series 37. 89 pp.

(52) Van Derwerker, Ralph J., and Johnson, Charles C. 1952. Refuse-can holders. Public Health Reports. **67**(8): 802-806.

(53) Van Derwerker, R. J. 1951. Sanitary landfill or incineration? The American City. **66**(3): 98-99.

(54) Van Derwerker, R. J. 1952. Sanitary landfills in northern States. Public Health Reports. **67**(3): 242-248.

(55) Watt, James, and Lindsay, D. R. 1948. Diarrheal disease control. Public Health Reports. **63**: 1319-1334.

(56) Weaver, L., and Keagy, D. 1952. The sanitary landfill in northern States. PHS Pub. No. 226. 31 pp. (Price 20¢).

(57) Weaver, Leo. 1956. The sanitary landfill. The American City. **71**(3): 122-124; **71**(4): 132-134, 169; **71**(5): 134-136, 167, 169, 170.

(58) Williams, E. R., Mallison, G. F., and Maier, P. P. 1958. Light equipment for small town sanitary landfill. Public Works. **89**(2): 89-91.

Bibliographies

(59) Refuse collection and disposal, a bibliography, 1951-1953. (Supplement to: Public Health Bibliography Series, No. 4) U. S. Dept. of Health, Education, and Welfare, Public Health Service, Washington, D. C. 39 pp.

(60) Refuse collection and disposal, an annotated bibliography, 1954-1955. (Supplement to: Public Health Bibliography Series, No. 4, Supplement B.) U. S. Dept. of Health, Education, and Welfare, Public Health Service, Washington, D. C. 32 pp.

(61) Wiley, John S. 1958. Composting of organic wastes, an annotated bibliography. U. S. Dept. of Health, Education, and Welfare, Public Health Service, Communicable Disease Center, Technical Development Laboratories, Savannah, Ga. 126 pp.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1960 O - 568911